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Water Works and Sewerage

Design - Construction - Collection - Treatment - Distribution - Disposal

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WATER & SEWERAGE WORKS

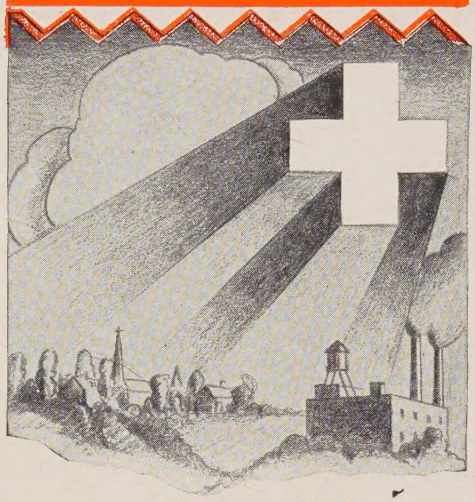
Design ~ Construction ~ Collection
Treatment ~ Distribution ~ Disposal

anuary, 1930 H. P. Gillette Editor Vol. LXXVII. No. 1

Zeolite Water Softening Plant at Sewickley, Pa.; Capacity 2,000,000 Gallons per Day

Member A. B. C.

HEALTHY CITIES are PROSPEROUS CITIES



SANITATION

A SCIENCE, whose benefits to community health record the advance of civilization. And sanitary engineers are registering new achievements through the treatment of sewage.

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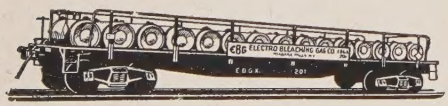

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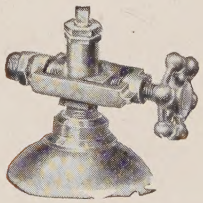

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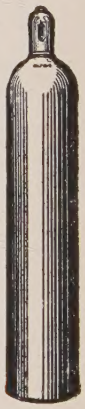

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Water Works and Sewerage

H. P. GILLETTE, Editor

Vol. LXXVII JANUARY, 1930 No. 1

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Water Works and Sewerage

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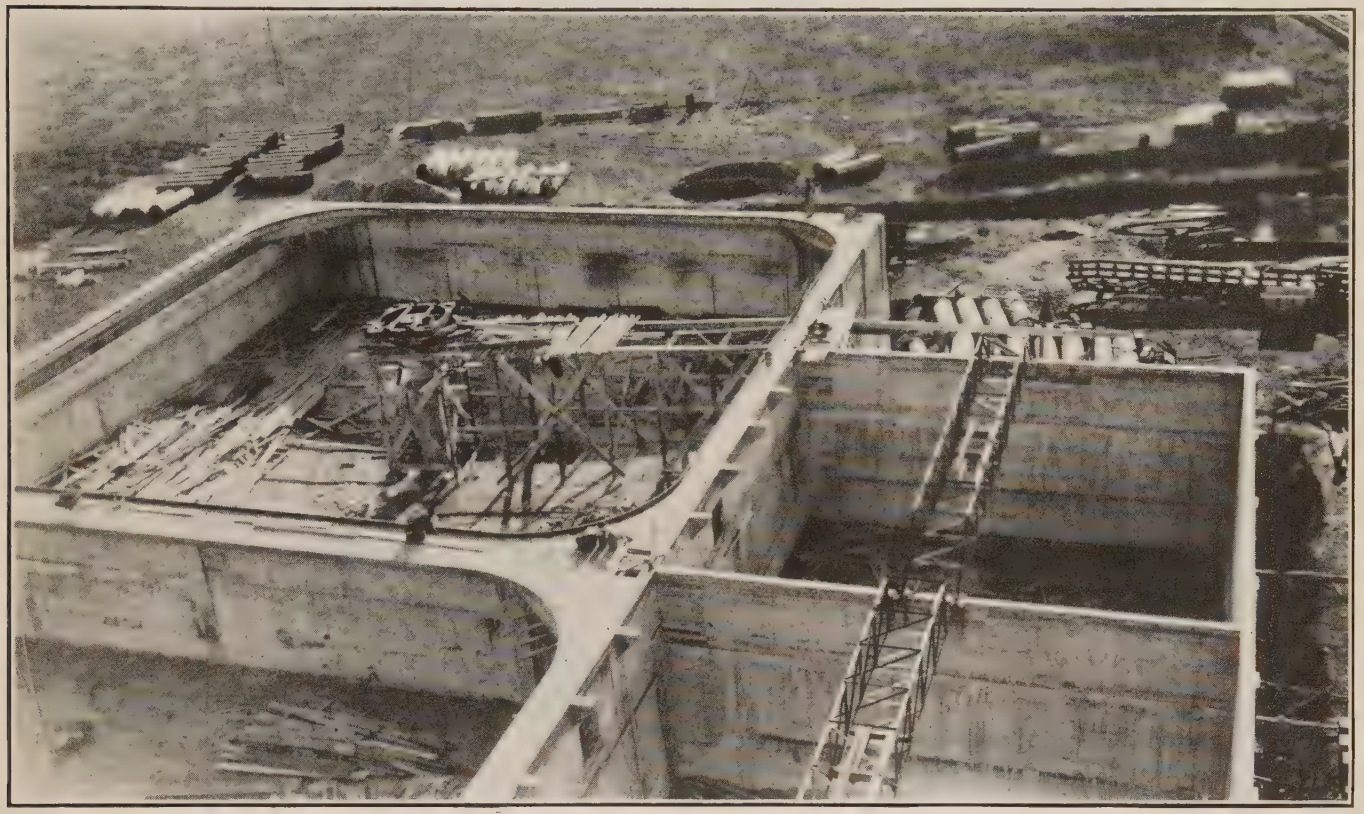


Construction View of Clarifier and Mixing Tanks

The New Water Works of Cedar Rapids, Ia.

Construction Features of the Combined High Lift Pumping Station and the 12,000,000-Gal. Daily Capacity Water Softening and Filtration Plant

By H. T. RUDGAL

Resident Engineer for Alvord, Burdick & Howson, Consulting Engineers, Chicago

THE new Cedar Rapids water works consists of a low lift pumping station and intake located on the east bank of Cedar River about three miles upstream from the city and a 12,000,000 gal. daily capacity softening and filtration plant located midway between the low service station and the city, opposite the beautifully wooded Shaver Park.

General Features.—The filters and clear well, suction channel and premixing tanks are included in the high lift pumping station and are built of reinforced concrete. Concrete is also used for all the pumping station substructures and floor slabs throughout the building. The superstructure is of masonry construction, with the roofs supported on steel trusses and beams.

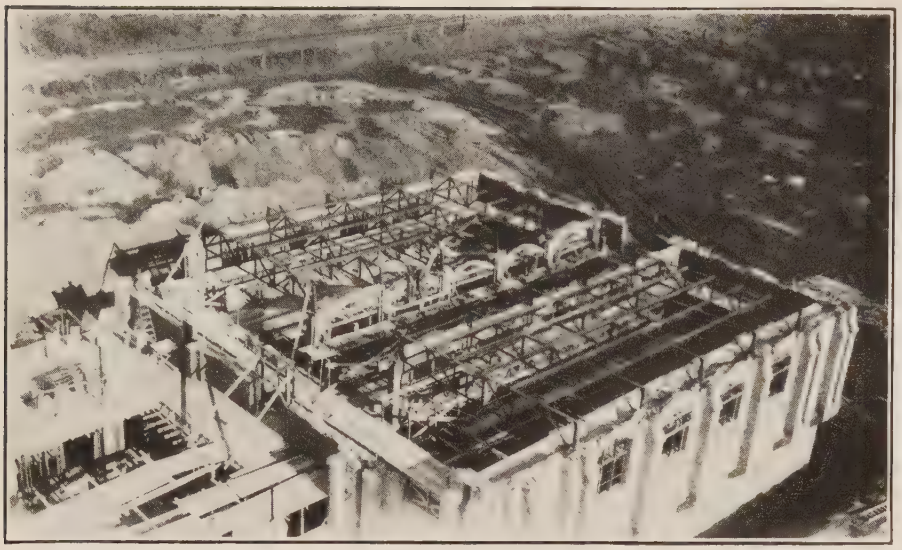
The high lift plant also includes two 50 ft. square mixing tanks 22.5 ft. deep, two clarifier tanks 100 ft. square with a saucer shaped bottom giving a depth of 16.5 ft. at the walls and 19.8 ft. in the center, and a carbonating tank 40 feet square and 16.5 ft. deep. These tanks are also of reinforced concrete construction.

The outside of the tanks will be backfilled with earth to within 1 ft. of the top of the tanks and at this level there is a berm 5 ft. wide. From this level the earth fill slopes down to grade with a slope of 1½:1. Earth fill will be carried around most of the pumping station building also.

A permanent siding from the C. R. I. & P. R. R. is a part of the new water plant and this was built prior to the general contractor starting construction work. It is needless to say that this track and the area adjacent to same has played an important part during the construction since all materials may be delivered right to the job in cars.

The Theodore Stark Construction Co., Inc., of Cedar Rapids, Iowa, was awarded the general contract for the job and with J. C. Gilbert as superintendent, work was started July 29, 1929.

Excavation.—At that time excavation for the clear wells was started and for this work a Speeder gasoline operated ¾ cu. yd. dragline outfit was used. The material encountered included loam, sandy clay and sand. The average depth of excavation for the clear wells was 15 ft. With the use of the dragline this excavation was done from outside the excavation proper and the earth loaded into trucks or 5 cu. yd. wagons to be delivered to the



Filter End of Building on Dec. 27, 1929

various spoil banks for use later as backfill.

The excavation for the pumping station building totaled 8,500 cu. yd. and the footing levels for the various units of the building varied quite extensively. However, the major portion of the excavation for the building was concentrated in the filter and clear well end of the building, the yardage here being 5,000 cu. yd. For the suction channel along the south side of the pump room a cut of 18 ft. is necessary whereas for the pump room proper, the cut was only 4 ft. Adjoining the pump room are the pre-mixing and CO_2 generator rooms, the excavation for these being 5 ft. and 13.5 ft., respectively.

A number of pipe trenches cross the pump room. These are about 5 ft. deep and vary in width from 4 to 6.5 ft. These cuts were made vertical and no caving of the sides of the excavation occurred, this permitting the use of the bank as the outside form for the concrete of the pipe trenches.

All final or finish grading was done by hand, but since the dragline work had been finished close to grade, the final grading was not a very big item.

Excavation for the building was of such a character that with cuts up to 18 ft. in depth, and only a slight slope of the sides of the excavation, little if any shoring was required. This helped speed up the work materially.

The excavation for the tanks totaled 7,400 cu. yd. and aside from the saucer shape bottom of the clarifier tanks, there was nothing of particular note to record about this work. The depth of cuts ranged from 1 to 15 ft. in depth, however. As in the pumping station excavation, the final grading was done by hand, insuring an even bearing surface right to grade.

Concrete Mixing Plant.—All reinforced concrete for the job was 1:2:4 mix to which was added 3 lb. of Celite per bag of cement. Hawkeye Portland Cement was used and the aggregates were river sand and crushed stone from quarries at Glory, Ia.

The concrete mixing plant was located adjacent to the siding track and between the pumping station building and the tanks. The plant consisted of a cement shed with a capacity of 3,500 bags of cement, 100 ft. high wood tower for chute distribution of concrete, elevated steel aggregate bins, and a 2-bag Koering mixer. The steel bins were equipped with Butler measuring hoppers and discharged into the mixer. The mixer was equipped with an accurate water measuring device which controlled the water for the concrete mix.

All aggregate was delivered to the job in cars and unloaded by a Speeder gasoline operated outfit using a ½ cu. yd. bucket. The storage piles for the sand and crushed stone were adjacent to the bins but since material could be received on rather short notice not much storage was carried. The schedule of shipping was so arranged that material would be received during times of concreting and the material then unloaded directly into the bins without rehandling.

Concreting Operations. — Concrete work started Aug. 29, 1929, and was completed Dec. 23, 1929. The high lift station structures required 4,400 cu. yd. of concrete and 418 tons of reinforcing steel. The reinforcing steel was rail steel furnished by the Laclede Steel Co. of St. Louis, Mo. The bars were all bent to proper shape at the mill after the reinforcing details had been checked by the resident engineer on the job.

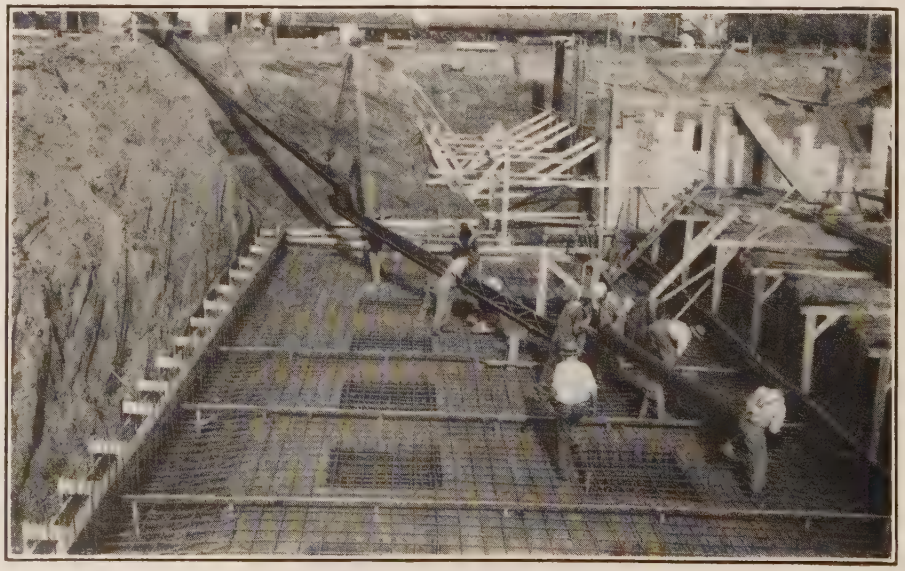
The first concrete poured was for the floors of the clear well and from then on concreting alternated between the pumping station building and the tanks. The concrete was quite evenly divided between the building and the tanks and totaled 2,226 cu. yd. for the tanks and 2,174 cu. yd. for the building.

Concrete was distributed from the tower to receiving hoppers and buggies were then used to further distribute same. The mixing plant functioned without a hitch throughout the job and no breakdowns occurred during any pour.

The major part of all the concrete is required to be water tight and special care was taken to spade all concrete thoroughly and good keyways were made at all joints. All exposed concrete is carborundum rubbed finish and for this purpose No. 24 Carborundum stones were used and the rubbing done by hand. In summer the forms were stripped 24 hours after the concrete had been placed and the rubbing done while the concrete was still somewhat green. The concrete walls throughout the job are excellent and all connected with the work are proud of the result.

The concrete yardage during the construction months was as follows:

	Cu. Yd.
August (2 days)	220
September	859
October	1,879
November	1,019
December	443



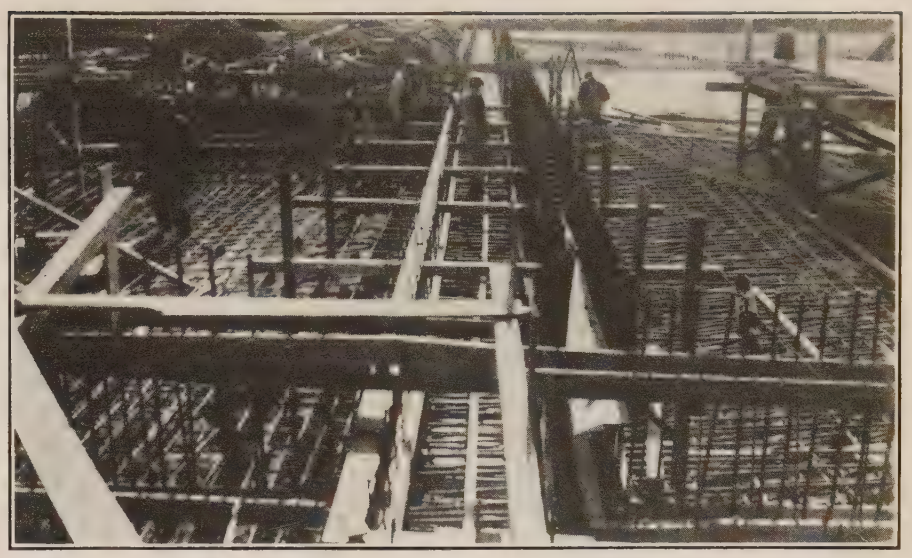
South Half of Clear Well, on Aug. 26, 1929

Cold Weather Concreting. — Some concrete was placed during freezing weather but concreting was never started with the temperature below 20° F. The concrete pours were also made smaller during cold working days so that all concrete would be placed during the day when the temperature would usually range somewhat higher than at night. Also during cold weather all aggregates would be heated by steam and warm water used in the mix, and should there be frost on the forms and steel a steam jet would be kept just ahead of the concrete to break up same. At the finish of any pour it would be canvassed in and salamanders kept burning until the concrete had set and no concrete was damaged at any time due to freezing.

Exceptionally good weather has prevailed since the start of the job and up to the present time the job has only been shut down four days on account of severe cold weather and two days due to rain. During this time, however, material was unloaded from cars making the time lost negligible.

The Form Work.—Lumber for formwork was delivered to the job in carload lots and stored along the track until needed. For the wall and slab forms panels were used and on the average these forms were used five times and are still in very good condition. These panels are built of 1x6 sheating, 2 ft. wide and held 2 ft. on centers with 1x4 wood cleats and are built in two lengths, 10 ft. and 14 ft. Prior to using they were oiled with parafine oil and after each stripping cleaned and oiled.

The studding for the form work was 4x4 dressed lumber and was spaced 2 ft. on centers. This spacing of the studding gave support to the panels, 1 ft. on centers, since the cleats on the panels are also 2 ft. spacing. This type or method of formwork gave a very rigid and easily erected form and one which was easily stripped also. The walers were built of two 2x6 members spaced ½ in. apart, permitting a ⅝ in. rod to pass between them. The form clamps used for all forms was the Universal clamp in conjunction with ⅜ in. tie rods.



Reinforcing Steel Layout at Tank

For supporting the various floor slab forms and cantilever projections of the tanks, adjustable shores were used and about 1,500 were in use during the concreting.

The pumping station concrete near the grade line was quite an intricate piece of formwork. At this level most of the walls are bracketed for brick work and with pilasters and areaways also to be formed at this level quite considerable time for formwork was necessary.

The walls for the tanks are cantilever type with the inside wall line being plumb and the batter in the walls being on the outside. Around the clarifier tanks there is a concrete cantilever projection for the support of the traction rail of the clarifier equipment and the influent and effluent troughs are also cantilevered out from the wall. The above concrete required a little more difficult forming than for the walls but there was nothing of particular note with regards to same.

The Exterior.—The exterior walls above grade of the pumping stations are faced with "Slag-Brix" manufactured by the Silica Brick & Eng. Co. of Chicago. All interior walls are of common brick manufactured by the Purington Paving Brick Co., Galesburg, Ill.

The stone base course and all trim is of artificial stone manufactured by the Chicago Architectural Stone Co., Chicago, Ill.

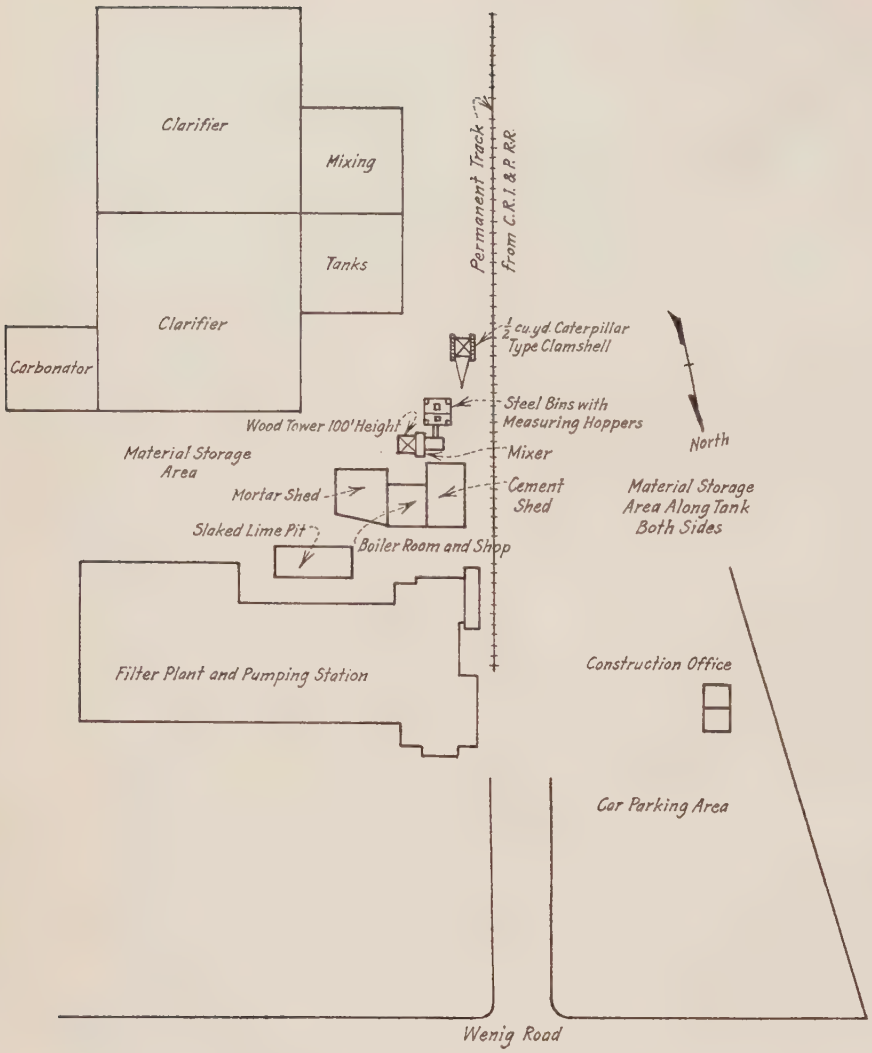
The mortar used for all brickwork is a portland cement mortar which matches the color of the face brick. The face brick joints are struck flush with every sixth course struck with a "V" joint giving the building a stone appearance. Care was taken to insure a match between the face brick and the stone and good results have been obtained.

For the pumping station building, 190 M face brick and 690 M common brick and 7,000 cu. ft. of cast stone are required. At the present time the brick work is approximately 13 per cent completed and this work was started in December. The contractor figures on working the bricklayers throughout the winter months on all days that the weather permits.

The mortar for the brickwork is mixed by a mechanical mortar mixer located in an enclosed and heated mortar shed. The sand is delivered at this time in trucks directly into the shed and during cold weather the sand is kept warm with steam. The brick after unloading from cars is covered and protected from the elements insuring dry brick for the work. The cast stone is shipped from Chicago and packed in excelsior and reaches the job in good condition.

The filter end of the building is practically completed as to brickwork and with this part of the building

South Side Filter End of Building on Dec., 27, 1929



Sketch Showing Layout of Construction Plant

finished the filter equipment contractor will be able to start work.

The filter equipment will be furnished and installed by the International Filter Co. of Chicago. Their materials have reached the job and it is expected to start this work in January.

The steel trusses at the filter end of the building have been set and also the structural steel columns and framing for the support of the wash water tank. The structural steel is furnished by the Iowa Steel & Iron Works of Cedar Rapids.

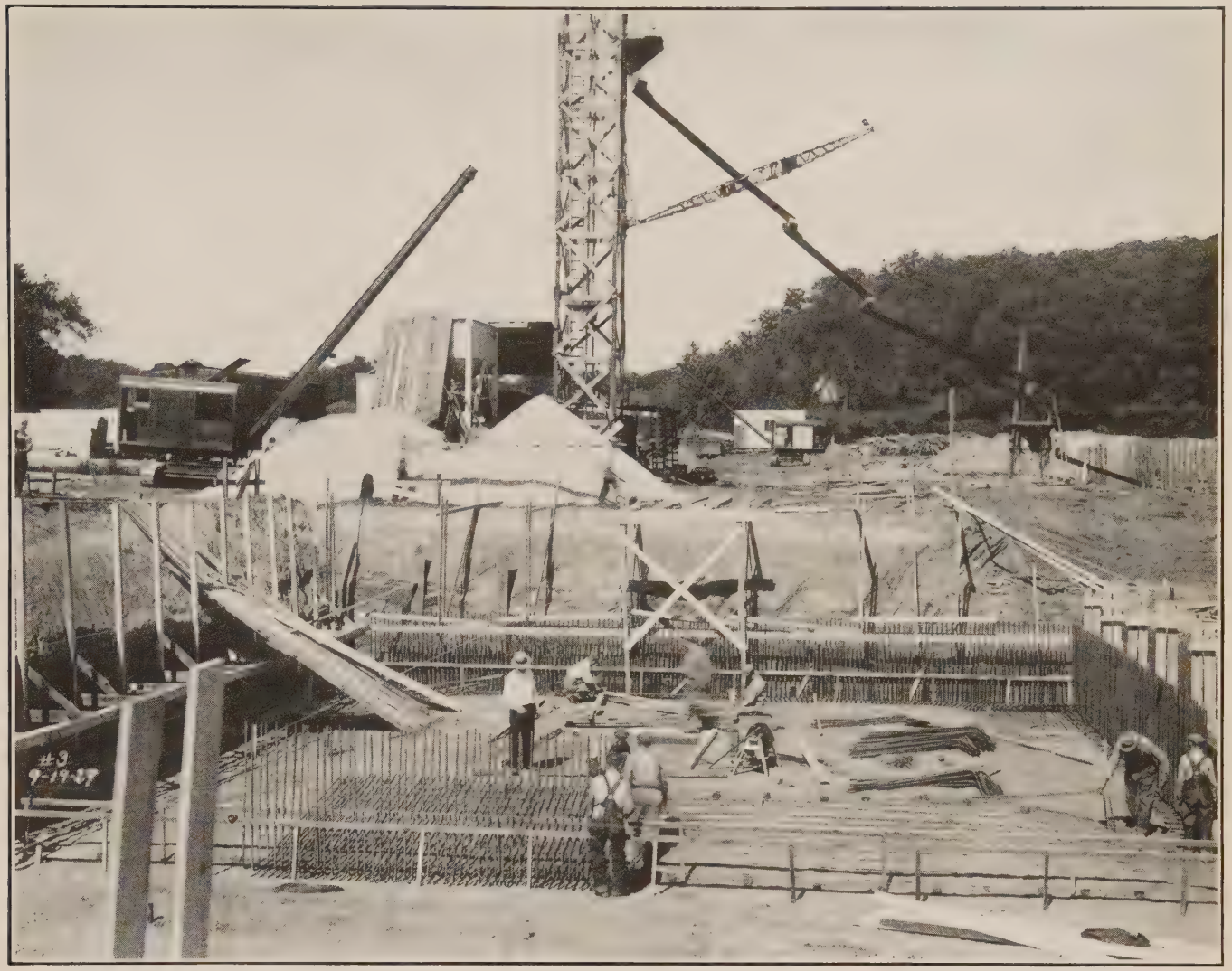
Ornamental iron for the job is manufactured by the C. W. Olson Manufacturing Co., Minneapolis, Minn.

A Dorr clarifier unit is being installed in the south clarifier tank.

The pumps and all equipment for the new water plant are electrically operated and the low lift or intake station is operated by remote control. This plant arrangement requires the installation of considerable electrical equipment and this work is being done for the general contractor by the H. J. Robertson Electric Co. of Cedar Rapids, Ia.

Piping.—For the station and yard piping cast iron pipe is being used, the size varying from 54 in. down to 6 in. Excluding the pipe gallery piping 73 tons of flange pipe and fittings and 362 tons of bell and spigot pipe are required to complete the installation. The sewers with the exception of a section of the wash water waste sewer are of vitrified tile and 780 ft. of 36 in. vitrified tile segmental block sewer has been completed at this time. All the

Perspective Drawing of the New Pumping Station and Filtration Plant of Cedar Rapids, Ia.



Concreting Plant Showing Tower and Chuting Arrangement for Placing the Concrete

outside or yard piping is being laid by the city water works pipe laying crew. The water works crew has also completed to date a 24 in. high service main to the new plant and the 30 in. low lift header from the intake station up to the high lift station.

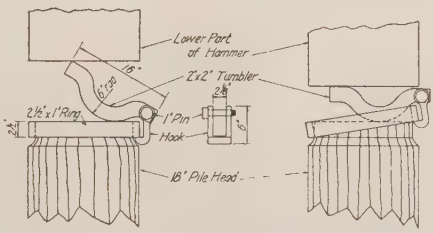
Work for the low lift or intake station has been confined to the driving of creosoted piles for the intake and the piles for the support of the pumping station building. With the concrete work completed at the high lift station the schedule is to push the work at the low lift location next.

The new water plant is scheduled for completion in July, 1930, and from the present outlook of the work it should be completed on time.

H. F. Blomquist is superintendent of the City Water Department. The new plant was designed by Alvord, Burdick & Howson, engineers, Chicago, who associated with them V. A. Matteson on architectural and Chas. P. Hoover on chemical features. The supervision of the construction is under the engineers who are represented on the job by H. T. Rudgal, resident engineer.

Simplifying the Removal of Head-Rings from Driven Piles

A useful device is the hook-and-tumbler arrangement shown in the accompanying illustration, used for removing head-rings from driven piles. The rings which are slipped over the heads of wooden piles while driving, to prevent splitting or "brooming," are used again and again, and accordingly a band must be removed once a pile has been driven. The blows of the pile-driver hammer result in wedging the pile head into the ring very tightly, and removal of the ring with ordinary tools such as hammers and bars is difficult.



Left—Device in Place with Tumbler on Top of Pile, Hook Under Ring and Hammer Falling. Right—A 6-In. Drop of the Pile-Driver Hammer Has Raised the Ring. Another Elevation of the Hook Is Shown in the Center

The sketch shows the action of the device clearly. When the pile has been driven, the tumbler or lever is placed on the top of the pile and the hook is caught under the ring. The hammer of the pile driver is now allowed to drop about 6 in., with the result that the ring is usually loosened a sufficient amount to allow of removal with a sledge. If the ring is still tightly wedged, the tumbler may be reversed and the hook caught under the opposite side of the ring. A second blow of the pile-driver hammer will free the ring.

This device will save labor and prevent damaging of the pile head. Even where it is necessary to cut off the heads of driven piles at a given elevation, it will be found easier to remove the rings by this method before sawing off the heads than to split the cut-offs to free the rings. The sizes of the parts may be altered to suit conditions, but the dimensions shown will be found convenient for most work.

Chlorination an Integral Part of Purification

THE following constitutes a digest of the report of H. W. Streeter, chairman, Committee on Water Purification and Treatment as presented to The Conference of State Sanitary Engineers in meeting at Minneapolis, Minn., Sept. 28-30, 1929.

Collective Study of Chlorination Efficiency.—The opinion of the committee is based upon chlorination data collected during a survey of more than thirty representative purification plants located in various sections of the country supplemented by experimental studies, both conducted by the United States Public Health Service.

The object in view was to throw light on the much debated question as to whether chlorination in conjunction with filtration processes should be considered purely as an "external factor of safety" or as an "integral part of purification" in such processes. Further than this an attempt has been made to set up a "normal efficiency ratio" for water chlorination and to determine if possible the extent to which it might be affected by such modifying factors as temperature, time, bacterial density and the extent to which chlorine-absorbing substances are present in the water. The conclusions reached as a result of these surveys and studies are briefly the following:

a. That chlorination must be regarded as something more than a "factor of safety" and should be considered an "integral part," and an essential part of filtration plant operation, is clearly indicated.

b. Unaided by chlorination the filtration processes employed on the large majority of raw waters delivered to plants in this country cannot produce effluents conforming to the Treasury Department B. Coli Standard.

c. For river waters of the Ohio type the limiting raw water B coli index corresponding to a standard quality of filter effluent without chlorination has been found to be about 60 per 100 cc. For Great Lakes waters the maximum appears to be less than 10 per 100 cc.

Effects of Time, Temperature and Chlorine Absorbing Substances.—As regards the effects of time, temperature and chlorine absorbing substances on the efficiency of chlorination, the experimental work of the Public Health Service has indicated, broadly, the following:

a. The time required to attain a given degree of bacterial reduction appears to bear a definite relationship to the average concentration of residual chlorine in the treated water during the period of such reduction.

b. The presence of chlorine absorbing substances affects the added amounts of chlorine necessary to produce a given efficiency, but the controlling factor in such efficiency appears to be the residual chlorine content rather than the amount of chlorine applied. The chlorine absorbing substances therefore exert but an indirect effect on chlorination efficiency.*

c. The bacterial efficiency of chlorination is affected by temperature, being somewhat greater at higher temperatures.

Raw Water Prechlorination. — Another phase of chlorination which received the committee's attention is the matter of raw-water prechlorination as a preliminary stage of treatment. The results of more than a year's study of the effects of prechlorination at the Public Health Service experimental filter plant at Cincinnati has rendered possible the following statement quoted from the report:

"Both the studies recorded by Enslow† and that made by the Public Health Service have indicated a clear gain in over-all bacterial efficiency effected through the use of prechlorination. The latter series of tests showed, also, that the maximum raw water B. coli index consistent with producing a final (rechlorinated) effluent conforming to the revised Treasury Department standard could be increased from about 10,000 per 100 cc. without prechlorination to about 25,000** per 100 cc. with prechlorination. Some observations recorded by Enslow have indicated that prechlorination results in a measurable economy in coagulants and in a lengthening of filter runs. Although the Public Health Service tests failed to confirm these two observations to any well-marked extent, they gave fairly clear evidence that prechlorination, if properly controlled, may be carried on without any material deterioration in the conditions of the filtering medium and with beneficial effects in minimizing plankton growth in sedimentation basins. In general, prechlorination appears to be establishing itself rapidly as an added stage of purification in connection with rapid sand filtration, particularly in the treatment of variable and highly polluted raw waters."

*Note: The controlling effect of residual chlorine is illustrated by appended efficiency curves comparing plants maintaining concentrations of residual chlorine just inside of the taste producing limits, with plants carrying as little residual chlorine in the filtered water as could be done with reasonable safety.

**Note: The committee chairman more recently advises that this figure will probably lie between 20,000 and 25,000 per 100 cc.

†Municipal News and Water Works, August, 1928; Western Waterworks, August, 1928; Canadian Engineer, Aug. 7 and 14, 1928; Jour. A. W. W. A., December, 1928.

The Pictorial Story of a Water Works

The story of Hackensack water is told in pictures which are being publicly exhibited at the district offices of the Hackensack Water Co., of Weehawken, N. J.

"Developing Your Water Supply" is the theme of three pictures in the Englewood office which tell of clearing the land, dredging the storage basin, and the new dam and the lake at Oradell—work which required ten years to complete.

A picture in the Westwood office entitled "Purifying Your Water Supply" depicts the operating room of the filtration plant at New Milford, showing control tables of sixteen filters which are on either side of the building. All water is filtered before being pumped.

Other pictures at Westwood are styled "Safeguarding Your Water Supply." They portray the laboratory at New Milford where the river water and the filtered water are sampled several times every day and tested to insure the purity and safety of the water delivered.

At the Ridgefield Park office, "Water in Reserve" shows the service reservoir in Weehawken, where water is held to equalize pressure and to furnish emergency supply. There are three such reservoirs in the southern part of the system. A second picture at Ridgefield Park bears the title "Collecting Your Water Supply," and shows the intake canal through which all water needed is brought from the upper Hackensack River into the station at New Milford.

"Pumping Your Water Supply" is the subject of the display at the Rutherford office. The 20,000,000-gal. pump at New Milford, one of four which sends water into towns, including Union City, Secaucus, Rutherford, Rochelle Park, Hillsdale, and Northvale, is portrayed. At Rutherford also pictures of two high pressure pumps at New Milford are exhibited. These pumps deliver water to the high service mains at a pressure of 230 lb. per square inch for use along the Palisades. Their capacity is 16,000,000 gal. per day.

At the Hackensack office scenes of more than a quarter-century ago evidence the influence of science and engineering in developing the modern water supply available to the 51 towns and cities supplied by the Hackensack Water Co. in Bergen and North Hudson counties.

Two pictures inscribed "Developing Your Water Supply" delineate "The Mill Pond in 1900" and "Old Dam and Mill." The theme is Veldran's old mill at Oradell, now replaced by the new dam and lake. A third picture at the Hackensack office is that of the settling reservoir at New Milford. It illustrates the process, "Purifying Your Water Supply."

The pictures, it is pointed out, indicate not only the development of the water system but also the scientific, economic, and social advance of this territory.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Filtration Engineer, Bureau of Engineering, Chicago, Ill.

The Rapid Sand Filter Bed

IN starting the section on filtration no subject would be more appropriate for the first discussion than the filter bed itself. It is passing the water through this part of the plant that gives us the name filtration. At first the filter beds were relied upon to do practically all the work of purifying the water, except that sedimentation prior to filtration was frequently used. Where fairly good results were desired it was essential to use fine sand and slow rates of filtration. As the construction of slow sand plants increased it was found that there were many waters where good clarification could not be obtained without some kind of pretreatment, especially for the highly turbid waters.

Chemical Treatment and Rapid Sand Filtration Developed.—The inability of slow sand filters to give satisfactory results at many places led to the use of chemical treatment for coagulating the suspended particles prior to filtration. The success of this method of treatment brought about many changes in plant construction. The chief changes in the filter beds were the use of coarser sand, higher rates of filtration, and provision for washing the sand in place by reversing the flow of water through the beds instead of scraping the surface as is the practice for slow sand filters. So many things may be accomplished by chemical treatment that in many plants the filter beds now play a minor part in the purification. Since the advent of rapid sand filters very few slow sand plants have been constructed. In fact so extensively has become this type of filtration that little space in the water purification literature need be given to slow sand beds. The present discussion will deal largely with how a sand bed of the rapid sand type removes the coagulated matter from water. Details of construction, operation, and filter bed troubles will be the subjects for future discussions.

Sand Beds for Rapid Sand Plants.—The sand beds for rapid sand plants are largely standardized along the following lines: Rectangular or round beds of most any size up to 1,500 sq. ft. of filtering surface, 24 to 30 in. of sand, 0.3 to 0.5 mm. diameter for the size, of which 10 per cent of the sand is finer, graded gravel for supporting the sand, and a system of underdrains. The water is passed downward through the beds at a maximum rate of 2 to 3 gal. per square foot per minute. Two gallons per minute is usually regarded as the rated capacity, but the majority of filter beds are operated at higher rates part of the time. The sand beds are washed by forcing filtered water through them in the reverse direction of filtration at a rate sufficient to partially suspend the sand. Fifteen gallons per square foot per minute is used for the washing rate in many plants. Air, and a slower washing rate was used extensively at first, but very few plants are now constructed for the use of air.

Voids in the Sand Beds Much Larger Than the Suspended Particles. — It should be evident that the method used for washing the filters leaves the sand about as loosely packed as is possible for it to be under water. When the sand is clean there is very little shrinkage during filtration due to the loss of head increasing as the bed becomes clogged, but where the sand grains have become coated with a gelatinous coating some beds have a shrinkage of 5 per cent or more by the time the loss of head reaches its maximum. This is responsible for cracks opening up in the surface and along the sidewalls of the filters in many filtration plants.

The arrangement of the sand grains in a filter bed might be compared to gravel of fairly uniform size dumped from a truck. It is evident that the dumping does not produce the minimum void area, and there are many open spaces almost as large as the average size particle making the mass. Openings fully one-half the size of such particles will be found leading into the pile for some distance. Many particles suspended in water are less than 0.001 mm. in diameter, and it should be evident that passageways through sand grains 0.3 to 0.5 mm. in diameter are many times larger than the finer particles, even though the sand be compact to its minimum void area. It is true that sand beds will remove particles much smaller than the voids, but when the grains are several hundred times larger than the particles it is evident that this is too great a difference for the removal of all suspended matter, especially if the removal is by lodgment of the particles in the sand voids. Coagulation is essential for this type of filtration, if the water is to be made perfectly clear.

Flocculated Matter Easily Filtered.—Examination of the flocculated matter produced by aluminum hydroxide and ferric hydroxide under the microscope reveals a surface quite irregular in shape. If a microscope could be made 50 to 100 times more powerful than the greatest magnification possible today, the structure likely would be found to be porous, being composed of a meshwork of irregular shaped fibers. With a substance so greatly expanded as aluminum hydroxide or ferric hydroxide it is evident that the mass must be quite porous. The irregular shape of the coagulated particles and the ease with which they may be forced into most any shape makes them ideal for lodgment in the wedge-shaped voids where two sand grains touch each other, or for a coagulated particle to attach itself to one already lodged. Deflection of the water at nearly every sand grain is also ideal for directing the coagulated particles into the wedge-shaped areas.

The average filter bed has a depth equal to the diameter of about 1,200 sand grains 0.5 mm. in diameter. A cubic foot of this size sand compacted to its maximum density will contain nearly 200 million sand grains. It seems reasonable to expect that there is an average of more than one wedge-shaped area for each grain of sand in a position to lodge coagulated particles. This means that every particle of coagulated matter passing beneath the surface of the sand bed has hundreds of places where it may become lodged, consequently there is practically no possibility of the particles passing through the beds. This is assuming

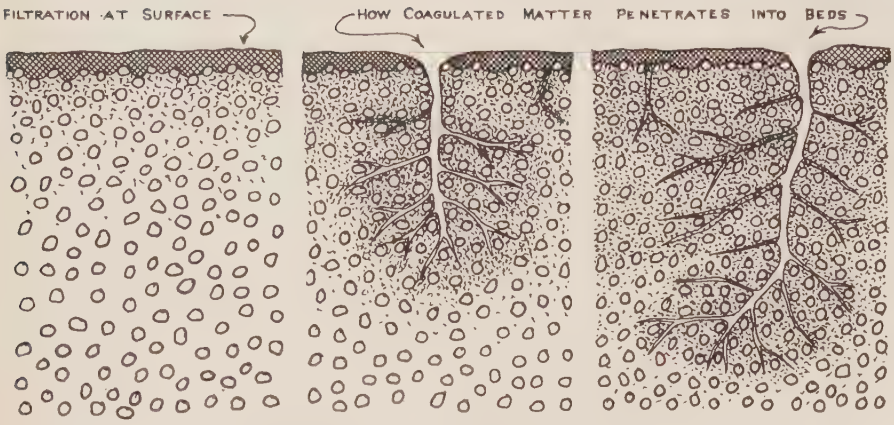


Fig. 1—Sketches Showing What Takes Place in a Filter Bed

that the bed has not channelized nearly to the bottom of the sand as will be explained later.

Filtration Is Largely by Straining and Lodgment of the Particles.—So far we have assumed that the removal of suspended particles passing the surface of the bed is by lodgment in the sand voids. It is likely that the sand grains in many filter beds have a gelatinous coating that not only aids the lodgment but it may have an attraction for the suspended matter. Some are of the opinion that these films are necessary for good turbidity removal and that the surface attraction is the main way in which the particles are removed. The writer puts little faith in this belief, for straining at the surface and lodgment beneath the surface accounts for the removal of practically all suspended matter removed by the filters. The gelatinous coating on the sand grains, however, is not a detriment providing it does not allow too much shrinkage of the beds. If it were possible to get filtering material with no attraction whatever for the coagulated matter and in which no gelatinous coating will form the turbidity removal would still be practically as effective as it now is for sand beds.

It is evident that much of the coagulated matter is removed by straining out at the surface of the sand. In fact for some waters the coagulated masses are formed so toughly there is little penetration into the beds. This is especially true where the water is not very turbid and contains many microörganisms. The mat on the surface forms so toughly it is not broken as the loss of head increases. Most of the coagulated matter that gets below the surface under this condition gets there before the mat forms tightly over the filter surface. This gives short filter runs, and the loss of head keeps increasing at an accelerated rate; that is, if the rate of increase was 1 ft. per hour when the filter was first put into service it might be 3 or 4 ft. per hour when the loss of head reaches 8 ft. If the flocculated matter is not reinforced by microörganisms, or strongly formed gelatinous matter, such as organic and silicious jellies, it is not strong enough to form a mat over the surface that will not break as the loss of head goes up. When the coagulated matter is not reinforced much of it penetrates into the sand bed, the filter runs are longer, and the loss of head increases nearly uniformly throughout the run.

How a Sand Bed Filters.—The sketches in Fig. 1 give the writer's conception of what takes place in a filter bed. They are not to scale and it is evident that the sand grains shown are not as compact as they actually exist in the filter bed. The sketches illustrate what takes place in the top 2 or 3 in. of the sand. The channels are shown larger than actual size, and are also shown in a nearly straight line. It should be evident that they make many turns within the distance of an inch. It would be difficult to show them as they actually exist, but the illustrations serve to show what takes place. It is this channelizing that throws much of the coagulated matter into the sand beds and gives fairly long filter runs. It is our aim in the treatment of water prior to filtration to produce conditions such that this penetration will take place, for no surface filtration will give filter runs within the bounds of what may be considered practical for the efficient operation of rapid sand filtration plants.

When the filter is put into service after washing the water enters the various openings at the top of the sand. The number of openings are perhaps in excess of 100,000 per square foot, and while many of the openings are filled almost immediately after the filter is thrown into service by the heavy coagulated particles not washed away during washing, the openings are still so abundant that the water enters the beds at a fairly slow velocity. Soon the accumulation of coagulated matter, both on the surface and in the bed at the surface, begins to offer resistance to the flow of water. Some of the coagulated matter is forced farther into the bed and that remaining on the surface is forced together more firmly. There is a checking of the flow at points and an increase in the flow at other places. Where there is an increase in the flow the coagulated matter is taken into the bed more rapidly and hastens the stopping up of the pores in that vicinity. The loss of head keeps increasing and the pressure compacts the mat more firmly, making it more resistant to the flow of water and more effective in straining the suspended matter. The mat must eventually break at points, or practically all additional filtration will be by straining at the surface. When the mat forms tough enough not to break it produces the condition shown by the left sketch in Fig. 1. A little of the sand near the surface may have the voids partially filled with coagulated matter, but the amount going beneath the surface is quite small compared to that removed in the mat at the surface. Neither aluminum hydroxide nor ferric hydroxide alone will produce flocculated matter tough enough to produce this condition with sand so coarse as is used in the average rapid sand bed.

Where there is penetration of the coagulated matter into the bed to any material extent the conditions shown in the center and right sketches in Fig. 1 prevail. At first the filtration is like that mentioned in the preceding paragraph, but more of the coagulated matter is taken beneath the surface at the start. When the loss of head builds up a little the mat is not tough enough to prevent breaks. Where breaks occur well defined channels are opened up from the surface down into the sand for a short distance. The channels take a portion of the water with its coagulated matter beneath the surface at very rapid rates. As filtration continues the beds reach a stage in which practically all water enters the sand through open channels. It is evident that the breaks do not all occur at once. It is a break here, there, and yonder, one minute, and elsewhere the next minute. The channels open to a point beneath the clogged sand, then the water begins to branch off in every direction. The water and coagulated matter flows through the channels at such a high velocity little or no coagulated matter is deposited along the sides of the channels in a manner to obstruct the flow. It is only after the velocity has been materially checked by branching that the coagulated matter lodges in the sand voids.

It is not a sudden change from filtration that is largely straining at the surface to filtration from channels beneath the surface, but a gradual transition. Some of the holes may open when the loss of head has increased only a few inches, others may not open until the loss of head has reached its maximum. Where most of the filtration is beneath the surface as is the case in the majority of plants it is likely that most of the holes which open up do so before the loss of head has increased more than about 2 ft. The channels probably

open before the voids within the sand near the surface are completely filled, and the opening of the channels do not at first stop the flow of water through other portions of the sand, but it lessens the flow. There is still a gradual filling of these voids from the surface, which very likely is aided by some flow from the channels. As this area becomes more thoroughly clogged there is a gradual reduction of the water flowing through the sand in the upper part of the bed except through channels. It should be evident that when the sand voids are nearly filled for an inch or more below the surface it is not likely that additional channels will open through the clogged area from the surface, but the flow will continue through the channels already formed by their being extended deeper into the sand bed as it becomes clogged.

Suspended matter depositing in the sand beyond the ends of the channels gradually clogs the sand and slows up the flow in the channels. Then part of the head which has been taken up by friction loss due to the rapid flow is transferred to a pressure head on the newly clogged area as the flow decreases. The head eventually reaches a point so great that channels are formed through the newly clogged area. The channels probably open in various directions, but the side channels have a limited area of voids to fill before the area is extended to where it comes in contact with other clogged areas. Perhaps it is well to mention that the clogged areas so frequently referred to in this discussion are not the same as the clogged areas frequently mentioned in the literature on filter bed troubles. We are now referring to clogging that is washed away each time the filter is washed.

As soon as the side channels branching from the main channels fill the voids in the area between the main channels, these channels gradually stop up with coagulated matter as is shown for the top side channels in the right sketch of Fig. 1. Many may be of the opinion that the coagulated matter is deposited at the top of the bed and is then gradually forced down through the openings, advancing the material which has previously deposited ahead of the freshly deposited material. If this was the way in which the material was forced farther into the bed there would be a constant disturbing of the coagulated material beneath the surface, which is not the case for most of the material filtered out. It is evident that some of the coagulated matter is occasionally dislodged and forced deeper into the bed, especially when a channel is forced through a clogged area, but this is believed to be a very small per cent of the total coagulated matter. It is the fresh coagulated material going into the bed that keeps extending the clogged area, largely by bypassing the material already deposited. If water having aluminum hydroxide coagulation was filtered through a bed until the pores of the sand were filled from the top down to about 2 in., and then water having ferric hydroxide coagulation was substituted, the ferric hydroxide would go beyond the zone of the aluminum hydroxide to be filtered out and would not advance the aluminum hydroxide ahead of it. There, of course, would be some mixing for filtration in any area is not stopped suddenly.

The number of holes that will open up in a given area of filter surface depends on many conditions. When the coagulated matter contains a certain amount of reinforcing material the holes may not start opening until the loss of head has increased 2 or 3 ft. By the time the main channels have extended 1 to 1.5 in. below the surface the friction head may be so great that the loss of head reaches its maximum. In this case the condition is somewhat like the center illustration in Fig. 1. Such conditions give moderate filter runs, perhaps from 10 to 20 hours when the amount of coagulated matter going on to the filters is not excessive. In this case there will not be the number of channels opening up for a given area as is the case when they start forming at a low loss of head. As previously stated, the coagulated matter will pass through the beds before the loss of head reaches 8 ft. under certain conditions. This is usually accompanied by a large number of channels.

When the coagulated matter extends 12 to 18 in. below the surface of the filter for 8 ft. loss of head, the writer has counted 12 to 15 holes per square inch through the surface of a bed having sand about 0.5 mm. in diameter for the 10 per cent size and 20 to 30 holes in sand about 0.3 mm. in diameter. It is likely that there are about as many channels through the sand as there are holes in the surface. With the large number of holes sometimes found in the surface there must be much mingling of the channels. Two or more channels may unite for a short distance and then branch again. What the water does is to find its easiest path through the filter. Sixteen holes per square inch is an average of one hole for each ¼ in. In this case there could not be much side branching of the channels as is shown by the illustrations. Usually the holes are not so abundant and 2 to 4 per square inch are perhaps about as many as should be expected with moderately long filter runs.

There is another effect that has not been taken into consideration so far in this discussion, and that is the contraction of the coagulated matter as the water is gradually forced out of it by pressure causing it to shrink in volume. We do not think it is possible for the water to be forced out of true jellies with the low pressure that can come into play on the coagulated matter in filter beds, but this coagulated matter is not a true jelly and will contract under pressure. As the compacting takes place it allows a small amount of additional material to be deposited in the clogged areas. It might be well to mention that in referring to the voids being clogged in a given area, they are not completely filled with coagulated matter. Such statements are to imply that the voids are filled to the extent that the flow of water through the area is nearly stopped.

With material so weak in structure as the deposits of flocculated material that is not reinforced in some manner

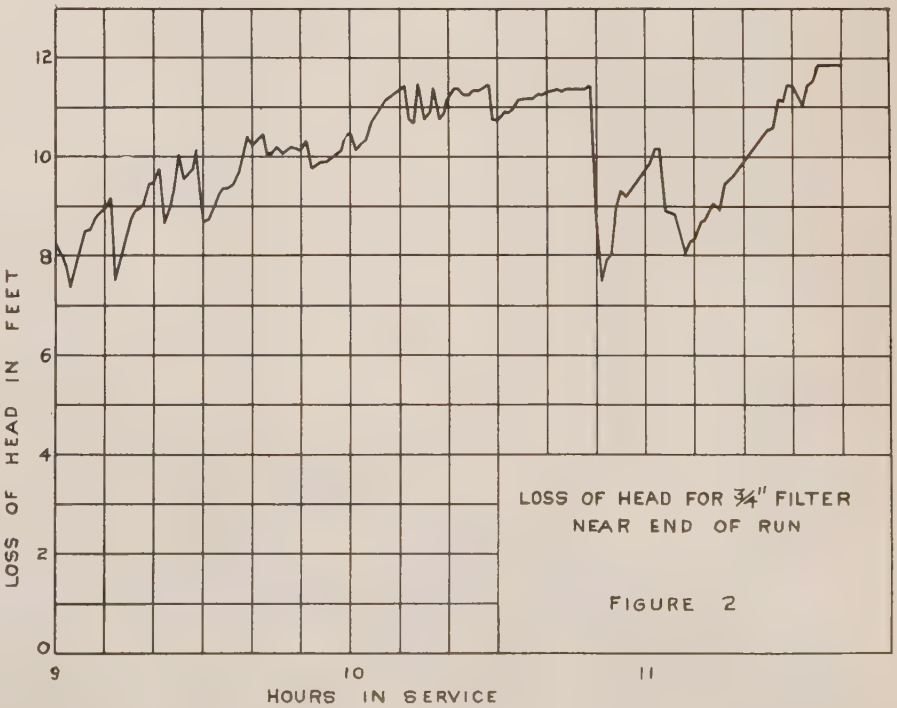


Fig. 2—Loss of Head Readings Taken at 1 Minute Intervals for About Three Hours

it is evident that it does not take much pressure to dislodge quite a great deal of the material and cause some of it to pass through the filter bed, especially if it already has a penetration of 4 to 8 in. Where there is considerable penetration of coagulated matter into filter beds care should be taken to see that the rate of flow through the bed is never increased suddenly. Water containing a great deal of coagulated matter may pass some of it in a very short time. It is more a matter of the volume of coagulated matter that a filter will remove before passing any of the coagulated matter than anything else. If water having a coagulated turbidity of 4 gives filter runs of 80 hours before passing coagulated matter, water with a coagulated turbidity of 400 might pass coagulated matter within an hour. There probably are several factors that will deviate the time from a direct ratio of the coagulated matter, but the volume certainly has the greater influence. With our present knowledge of the influences affecting coagulation it is difficult to predict filter runs or penetration of the material into the beds. No specific rule for filter plant design can be given. The writer favors a treatment prior to filtration that will give a coagulated turbidity of not more than 5. Sometimes this is difficult to attain and it is more economical to handle higher turbidities on the filters, but it is never desirable to purposely throw more coagulated matter on to the beds, as was the belief of many a few years ago. The best procedure is to get the coagulated turbidity as low as is practical with a reasonable expenditure, and then filter out the balance. Perhaps some day the value of the factors influencing toughness of coagulation and filtration can be fixed more definitely.

Observations on Filter Beds.—Some years ago the writer made many observations on what takes place in a filter bed. The work was done largely to determine the cause of cracks and clogged areas in filter beds; however, many observations were made on glass tube filters. Very interesting results were obtained with a glass tube filter approximately ¾ in. inside diameter. This was such a small area that frequently only one hole formed through the surface. It also was small enough so that the effect of the breaks would show on the mercury gauge. Figure 2 shows the loss of head readings taken at one minute intervals for about 3 hours at the latter part of the run. The breaks are defined by the sudden drops in the loss of head. It is believed that most of the sudden drops of about 1 to 2 ft. were caused from side channels opening from the main channel, and that the drop of nearly 4 ft. was caused by the main channel being extended deeper into the sand. This is what is happening over the entire surface of a filter bed, but the breaks do not occur all at once and there is no measureable effect on the loss of head gauge. In fact, filters one and three-fourths inches in diameter do not show much of a jump when a break occurs, for there are usually 6 or more holes in this size filter.

Water Is Variable in Character.—If water was uniform in its characteristics throughout the year its filtering qualities could be determined and the sand used which would be most suitable. Water from a certain supply may vary quite widely throughout the year. In the warmer months it may be difficult to get filter runs long enough for efficient operation, and in the winter months coagulated matter may pass the beds before the loss of head reaches 4 ft. Some waters may go from extreme toughness in coagulation to extreme weakness within a few weeks, indicating the temperature is not the main factor. When the coagulated matter is extremely tough sand 0.5 mm. in diameter for the 10 per cent size and 4 to 5 in. in depth would be sufficient to filter the water clear, but where it is extremely weak sand 0.35 mm. in would require a bed about 4 to 6 ft. in depth to prevent coagulated matter passing the beds if the filters were run to 8 ft. loss of head. Finer sand will have excessive shrinkage and cracks will open, so it is not feasible to solve the trouble by using finer sand. Neither is it feasible to have sand beds 4 to 6 ft. in depth. The most practical thing to do is to wash the filters with a lower loss of head. A bed 24 in. deep will give 40 to 60 hours service before passing coagulated matter under most conditions if there is fairly good settling in the settling basins, and this is long enough for the efficient operation of filters. Any filtration plant having filter runs in excess of 40 hours over any period of the year should be equipped with floc detectors so that the beds may be washed if the coagulated matter starts to go through.

Water in 1877

The Proceedings of the American Society of Civil Engineers has been publishing extracts from a pamphlet written in 1877 by one of its members. Here is what he has to say concerning a water works of that time:

"We visited the water works at Sedalia. They are very extensive. The water is first ground (three-fourths), as I understand it, in order to give the particles held in solution required fineness. It is then allowed to settle, and the surface is drawn off with pipes which lead to the breweries. It looks better as beer; like the eggs the restaurant cook wanted to scramble when a customer ordered them boiled. This was all explained to me in detail by the gentleman who put up the mill for the city, but I can only give an outline of the process here."

Cost of Filter Plant Operation

The water purification plant operated by the Essex Borders Utilities Commission, Windsor, Ontario, has a nominal capacity of 21,000,000 Imperial gallons per day and serves approximately 120,000 people in nine communities. In a paper presented at the 1929 convention of the American Water Works Association, J. Clark Keith, chief engineer of the commission, gave the following cost data on the operation of the plant:

The operating costs for 1928 amounted to $12.58 per 1,000,000 gal. filtered, the percentages of this total being:

	Per cent
Wages	34.1
Power	21.7
Coagulants	16.7
Overhead, taxes, rentals	10.3
Depreciation	5.5
Miscellaneous supplies	3.8
Grounds, and building maintenance	2.8
Heating	2.2
Plant, maintenance	1.6
Laboratory	1.2

The plant is electrically operated with power supplied by the Hydro-Electric Power Commission of Ontario. The rates are $1 per horsepower per month, based on the peak load, 2¼ ct. per kilowatt for the first 50 hours, 1½ ct. for the second 50 hours and 0.33 ct. for all additional power.

The average cost of coagulants per million gallons was $2.09, which incuded the added cost of lime and iron coagulation. During the period when lime and iron coagulation was employed, the average cost per 1,000,000 gal. was $4.09. Alum coagulation during the balance of the year represented an average charge of $.171 per 1,000,000 gal. filtered.

Salaries represented $4.28 of this sum, power $2.74, overhead $2.33, coagulents $2.09 and maintenance $1.24.

The operating staff includes a superintendent, a chief operating engineer, a chief filter operator, three operating engineers, two filter operators and a utility man. The lowest wage paid is 62½ ct. per hour.

The total power consumption for 1928 was $1,455,000 kilowatt-hours, costing an average of 0.82 ct. per kilowatt-hour. The pumping cost for power alone, exclusive of wash water, averages $2.55 per 1,000,000 gal., or 6.7 ct. to raise 1,000,000 gal. 1 ft.

Overhead charges include supervision, rentals paid for use of railway right-of-way, taxes and insurance. A depreciation reserve of $3,000 is set aside annually to replace the heating system, motors and pumps which will need replacement within the 30-year life of the debentures.

Maintenance charges include the general upkeep of machinery, buildings and grounds and the purchase of miscellaneous supplies required in this work. The grounds are attractively maintained as water works plants should be.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor
Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

IN the northern part of the United States the months of January and February find outdoor activities about the average sewage works at a low ebb. It is during this period that the operator finds time to take stock of his plant condition and plan for the spring rush of work which bursts suddenly upon him after the middle of March.

For one thing it is a good time to make leisurely comparisons of analytical data which we have had little more than time to jot down during warm weather. Comparison of data over equivalent periods of time during a number of years is very interesting and instructive.

We may talk of early springs and late springs but it is surprising to note how consistently the white growth (often spoken of as Leptomitus) begin to loosen from the interior of the sewer lines and come into the plant during a certain week of the year; or how closely we may predict the time of the spring unloading of trickling filters.

Trickling filters are particularly sensitive to these seasonal changes. Nitrate oxidation begins to fall off late in the fall reaching a minimum in February. If the connected population is increasing, the rate of fall and the depth of the minimum will increase noticeably from year to year as the plant's capacity is approached. If one is not determining nitrates as a routine matter, a comparison of the results of the methylene blue tests will indicate this increasing winter sag as the capacity becomes taxed nearer to the limit. The magnitude of the variations in oxidation during weekly cycles is also indicative of the approach to bed capacity. That is to say, a plant with abundant capacity will hardly show the weekly cycle, but a trickling filter approaching capacity will show a decided increase in oxidation after the Sunday recuperation due to weak sewage on that day. The decrease in oxidation during the balance of the week will indicate to the experienced operator the margin of reserve powers.

Time Records

In January also the operator is planning the year's budget, is probably making an effort to secure special appropriations for improvements the need of which has been brought home to him by comparison of laboratory operating data. All too often he will have to secure these appropriations from new councilmen or new committeemen who are taking charge of the plant at the beginning of the year and are entirely unfamiliar with the work.

A good time record will be found very valuable in presenting the needs to the committee in charge; not that the time record should be handed over to the committee as such. Human nature is a funny thing; a nice neat tabulation of this kind presented to a newly made, ambitious councilman who is, perhaps, overfeeling the importance of his new station, might produce a number of unlooked for reactions. For instance, it might send him off on a wild economizing spree with very unfortunate results.

The thought which we wish to express is, that the operator should have a personal record of the time spent on various parts of the plant so that when he sees the need for a particular improvement he may be able to state with confidence the exact effect on the economical management of the works. Below is a typical week's record of a plant consisting of fine screen, Imhoff tanks, sprinkling filters and resettling tank, where the sludge is moved by a team.

There are, of course, many little items which we cover under Odd Jobs. We do not burden ourselves with splitting time beyond the nearest half-hour because our object is to produce a bold picture showing in relief the main time absorbing items.

The below sample record would assist in answering the following questions: Would a tractor be more economical than a team for hauling sludge? (Note the fixed loss daily in caring for barn and team.) Would it pay to install separate settling tanks with mechanical sludge removal? (Note time spent on various parts of Imhoff tanks.) Would it pay to install a sand trap? (The week chosen is one of perhaps five during the year in which a settling tank has been shut down for removal of sand.)

At one plant such a record was summarized as follows:

Night watchman	$ 4.50
Care of tanks	13.50
Balance of plant	6.50
Total daily cost of operation	$24.50

The care of tanks runs into the sizable item of $4,000 for 300 working days, or almost exactly 50 per cent of the annual labor charge. This $4,000 also equals 6 per cent interest on $65,000 and calls for careful consideration of the possibility of reducing costs by installing separate settling tanks and mechanical sludge removers.

Data on Sewage Solids

A record of suspended solids in settling tank influent and effluent is very instructive and is essential to intelligent operation. On page 12 is a typical 10-year record covering suspended solids in tank influent and effluent expressed as parts per million, and solids retained, expressed as parts per million as well as in pounds of solids retained and as cubic feet of resultant sludge. Together with the solids record are given the rainfall, sewage flow, and estimated contributing population.

This table helps to explain many things. The fact that the flow of sewage in M.G.D. remains fixed while the population has steadily grown is due to the fact that metering of the water services in the tributary territory has been progressive over the period and

Labor Distribution at a Disposal Plant

Item	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Barn	2:00	2:00	2:00	2:00	2:00	2:00	2:00
Screenings		1:00	1:00	1:00	1:00	1:00	1:00
Watchman	22:00	14:00	14:00	14:00	14:00	14:00	14:00
Sludge pump					4:00		
Imhoff tanks							
Set. compartments		8:00	8:00	:30	1:00	2:00	1:00
Vents		5:00	14:00	8:00		4:00	5:00
Slots		5:00	2:00	2:00	10:00	3:00	5:00
Final tank						16:00	16:00
Cart sludge		7:00	7:00	7:00	6:00		
Spray flies		1:00	1:00	1:00	1:00	1:00	1:00
Care grounds						10:00	
Sand from tanks		8:00	16:00	16:00	18:00	12:00	12:00
Clean nozzles							

Data on Sewage Solids

Year	Rain Inches	Parts per Million Screened	Settled	S. Solids Retained	DAILY Flow MGD	Pounds Retained	Cu. Ft. 95-5%	Population Mid-Year	Per Cent Solid Retained
1920	41	161	66	95	3.7	2,945	942	34,500	59
1921	38	150	59	91	3.2	2,411	777	35,700	60
1922	40	147	77	70	3.3	1,925	616	36,800	48
1923	36	188	89	99	3.3	2,722	671	38,500	52
1924	46	212	120	92	3.3	2,530	809	40,500	43
1925	39	216	96	120	3.2	3,202	1,024	42,300	55
1926	44	218	92	126	3.3	3,357	1,074	45,550	58
1927	46	230	104	126	3.3	3,465	1,107	48,000	55
1928	46	223	100	123	3.5	3,567	1,139	53,500	55
1929	41	234	111	123	3.5	3,567	1,139	53,795	53

has recently reached nearly 100 per cent, reducing per capita consumption from 100 gal. to little over 60 gal. The increase in suspended solids in the screened sewage checks this statement.

The increase in suspended solids retained subsequent to 1924 is due to changing from Imhoff tanks to separate settling tanks.

The apparent reduction in suspended solids retained in 1929 from 55 per cent to 53 per cent is probably due to the fact that during this year a sand trap was in operation and removed a weight of quickly falling solids equal to nearly 6 per cent of the suspended solids in the screened sewage. Not all of this would have reached the screen effluent had the sand trap not been in operation, but certainly a portion of it would have done so.

A very complete record of house connections has always been kept in connection with this plant and is a record which is recommended in every case. The population is estimated by multiplying the number of individual house connections by 5.

As previously indicated the purpose of these notes is to interest the operator in keeping records and to interest his superior in supplying him with the equipment for securing proper records, and to interest city officials in general in the value of employing operators who are capable of making chemical determinations and keeping proper records.

Dosing Siphons

Except that they gradually become somewhat sluggish in action, over a period of years, dosing siphons of the air lock type, with no moving parts, give so little trouble that one is more or less at a loss when they do fail to work properly.

Recently one of these siphons under the writer's supervision became so sluggish that an inordinate proportion of the flow was diverted to another section of the sprinkling filters with a consequent drop in the quality of the effluent. A description of the method of handling the situation may be helpful to operators of other plants.

The plant has two independent siphons, each supplying one-half the filter bed area from a common source. Hence any slowing up of one siphon would result in under-dosing one-half the bed and over-dosing the other half. The flow is so great that one siphon alone will take the entire flow only in the early morning hours. The time available for discovering and correcting the difficulty is, therefore, very much limited.

When the flow of sewage to the plant was very low the supply to the faulty siphon was cut off by means of stop planks just after this siphon had started to operate. When the discharge was complete hasty examinations were made and such obvious possible difficulties as sticks or grease balls in the elbows of the trap piping were eliminated.

Finally, realizing that time for a more than casual inspection was imperative, we set a 3 in. diaphragm pump of the ball valve type in such a position that it would take care of any seepage through the stop planks and set to work very early in the morning. All the trap piping was taken down and all pipe and elbows found to be clear. But it was found that the entire inside of the siphon bell was coated to a depth of an inch or more with grease and that this grease had "grown" entirely across the 1¼ in. orifice leading to the trap. The surprising thing about it was that the siphon worked at all under these conditions.

When the grease was cleared out of the orifice this siphon was found to make 193 shots per day as compared with 115 for a comparable flow before cleaning. The difference is made up of the few seconds per shot necessary to force the air out of the plugged hole and the quantity of sewage previously diverted to the other siphon.

With the balance between the two sides of the filter, and the balance between the discharge and resting periods restored, the quality of the filter effluent began to improve immediately.

Reverting again to the matter of records; it was only because of the fact that records of the number of siphon doses were available that we were able to explain the slump in effluent quality and to correct the trouble before it became even more serious.

In connection with our remarks in the December, 1929, article on Developments in the Art of Sewage Disposal, Chas. C. Hommon, Superintendent of Sewage Disposal for the City of Canton, O., has kindly prepared the following notes on controlling growths and deposits in sewage trickling filters:

Controlling Growths and Deposits in Sewage Trickling Filters

By CHAS. C. HOMMON

During the past two years the writer has had opportunity of visiting some seventy-five sewage treatment plants, employing trickling filters, to determine among other things the cleanliness of the aggregate. The many observations enabled one to draw the conclusion that many of the filters were retaining excessive amounts of organic deposits, regardless of the type of filtering material employed. Many of the beds were excessively dirty and others were clogged to the extent of surface pooling, some of them resembling miniature lakes. Laboratory data to show the efficiency of the more seriously clogged beds were not available, but it is assumed that but little nitrification is possible under such conditions. Inquiry from the plant superintendent as to what was being done to relieve the stoppage usually brought forth the statement that sooner or later the bed would automatically unload and that eventually all would be well. The writer has experienced many uncomfortable intervals waiting for nature to take its course in such matters. In most instances nature has been quite successful in maintaining the filters in such condition as to permit reasonable use of the filters but has often failed in completely renovating the aggregate.

To determine the feasibility of controlling the surface algae growths and organic accumulations that are normally deposited in sewage filters considerable care has been given to the operation of the filters at the Canton, Ohio, plant.

The Canton sewage works were placed in service during the spring of 1927. The filter area consists of 6.75 acres, divided into four units, each unit being provided with a suitable sluice gate for flooding the filtering material. The filters have a nominal depth of 7 ft. and are filled with crushed blast furnace slag ranging in size from 1½ in. to 2¾ in. in diameter. The filters were designed for a population load of 8,855 per acre foot and the estimated present load is 2,330 persons.

During the first year of operation the total filtering area was maintained in continuous service after which time the aggregate was what may be called normally dirty; in some areas the voids were practically filled with black deposits and some slight evidence of surface ponding was noticeable. On one occasion prior to 1928 a slight unloading occurred but not sufficiently complete to say that the filters were clean. Beginning in late Spring of 1928 a systematic resting and flooding schedule was established and followed until the present time with the exception that during the colder months of the year flooding is omitted. Numerous inspec-

tions of the surface of the beds, together with a number of test pits dug to varying depths at different points in the filters, indicate that the aggregate is practically as free from organic deposits as when it was placed at the time of construction. A recent failure of a part of the concrete collecting gallery served to show very clearly the cleanliness of the aggregate. At the time of failure of the concrete wall a considerable quantity of the slag was washed out of the filter into the effluent channel, exposing the slag within the bed from the top to the underdrains. With the exception of a few small areas, where some fine aggregate existed, there were practically no organic deposits noted, and the underdrains were likewise quite free from foreign deposits. Comparing the condition of the filtering material after approximately one year's service under what may be called normal operating conditions with that of two years' service during which time periodical drying and flooding was practiced, it appears that one is justified in believing that it is possible to control the cleanliness of the filtering aggregate within rather close limits.

The cutting out of service of any one of the filter units during the drying period necessarily increased the load on the remaining active units but this increase has not materially affected the efficiency as nearly as can be determined by the usual laboratory analysis of the effluent. As previously noted the present estimated filter load is 2,330 persons per acre foot which is increased to approximately 3,100 persons per acre foot during the time of resting one of the units. In practice it means that the filters have been operated for the past two years at the higher rate for the reason that at all times at least one bed has been out of service. For experimental purposes the rate has been increased to 4,660 persons per acre foot for periods up to three weeks. During these high rates of application the nitrification was reduced somewhat but not to the point of materially affecting the general character of the filter effluent.

If the experience at Canton may be taken as a criterion there appears to be no doubt that it is feasible and desirable to control the deposits that normally collect in sewage trickling filters. Cleanliness not only promotes more satisfactory operation of sewage sprinkling filters but perhaps will permit of higher rates of application of sewage and greater length of service.

Sewage Treatment at Philadelphia

The following is a statement by Mr. John E. Allen, Principal Assistant Engineer, Bureau of Surveys of the City of Philadelphia, with regard to the matter of future treatment of sewage in that city as referred to in our December article:

"The City of Philadelphia is faced with the condition at the Northeast Works of insufficient diluting water to receive the discharge from the Northeast Works without additional refinements to the present Imhoff tank process. Research work, which has been carried on for several years, indicates that the Imhoff treatment will be superseded by aeration of sewage, sedimentation, a continuous removal of deposited solids, and the incineration of these solids. The results of this research work indicate the almost complete removal of settleable and suspended solids and over a 90 per cent removal of bacteria. This will, of course, increase the amount of sludge to an extent that makes desirable some method of reducing the bulk and facilitating the final disposal. It is hoped to obtain this by incineration and experimental work has shown a destruction of organic matter and a reduction in bulk to about 15 per cent of ash by burning. The design of incinerator under study is intended to receive the sludge as it is delivered from the sedimentation stage and without intermediate de-watering machinery.

The entire sewage treatment program of the City of Philadelphia anticipates the handling of 1,100,000,000 gal. daily and the resulting sludge volume under this process is estimated at 5,000 cu. yd. daily of wet sludge. This result desired has not yet been attained in the incinerator designed but experimental work gives promise to success."

Cleaning Submerged Outfall Sewer

The cleaning of the under-sea section of the outfall sewer of the city of Santa Barbara, Calif., involved some interesting methods which are described in a recent issue of the California Constructor.

The 42 in. line extends 3,400 ft. into the ocean and at its outer end is 50 ft. below the surface. The earthquake of 1925 caused movement that separated some of the joints so that sand has been filtering into the pipe through crevasses at the joints, clogging the interior to such an extent that sewage, which is forced down the pipe by pump, cannot reach the lower end of the line. During the past summer the sewage has been discharging through a manhole in the line 300 ft. from the beach.

The contract let to Charles H. Johnston, Los Angeles, Calif., at $40,000, called for the cleaning of the sand from the line, and for the re-caulking of the joints. The cleaning work was accomplished by two divers who worked inside of the line, and who were tended from a barge above them that also carried sand pumps. The two men also re-caulked the joints, using air hammers for this work.

The methods employed were similar to sand moving work on shore, adapted to the conditions of the job. One of the features of the work was the employment of the two divers, who spent seven hours per day under water for a four month period. The maximum depth of 50 ft. at which they worked was not excessive, but there have been very few single jobs in the past in which divers have been called upon to spend so large amount of time beneath the surface.

The divers were fitted out in regulation Navy diving gear and carrying telephone sets. Each was assisted by a tender on the barge. The barge had a crew of one engineer and two seamen, who operated the sand pump, the telephones, and the air compressor. The air compressor discharged into a reservoir that contained a maximum of a half hour supply of air. An auxiliary hand air pump was connected into the air lines, so that in case of failure of the air compressor, the divers could be fed from the hand pump and from the reservoir.

Operations began from the beach end of the sewer line. Manholes are 250 ft. between centers on the pipe. After the barge was spotted above the first manhole, the divers descended and pulled off the manhole cover. An 8-in. suction line was dropped from the barge to the divers, who pulled it into the sewer line. The line was found to be nearly full of sand, except for a space of from 6 in. to 1 ft. along the top. The end of the suction line was forced into the sand, which was carried through the pump on the barge and discharged over the side.

The divers worked in absolute darkness inside of the sewer line and had a great deal of difficulty in handling the heavy suction line. By squirming along the top of the sand, the divers were able to insert a trench jack across the sewer line some distance ahead of their work. A steel cable from a winch on the barge was passed through a block attached to the jack and was tied on to the end of the suction line. By speaking through their telephone sets, the divers were able to direct the barge attendants to operate the winch, dragging the suction line further into the sewer as the work progressed. A steel cable was lashed to the suction line and took the pull of the winch.

Cleaning was done from manhole to manhole, after which the section was walled up to prevent the sewage from following the work of the divers, it meanwhile discharging through the manholes, which were left open. The sewer line was "swept out" after most of the sand had been pumped away, with a 2-in. jet of water under 100 lb. pressure.

C. D. Curry was superintendent for the contractor.

Alternate Wet and Dry Periods of 11.2 Years Shown by California Sequoias for 3125 Years

By HALBERT P. GILLETTE

IN *Water Works and Sewerage*, November, 1929, it was shown that the rainfall records of central and southern California disclose an alternation of wet and dry periods of 11.2 years, and that this same periodic alternation can be traced back for 500 years in the radial growth of Arizona pines. In the present article an account will be given of a similar alternation disclosed by study of the annual ring thicknesses of the California giant redwoods or sequoias.

The measurements of sequoia annual growth are those made by Prof. A. E. Douglass of the University of Arizona ("Climatic Cycles and Tree Growth," pub. by Carnegie Institution). From study of his measurements of tree rings Prof. Douglas inferred that about every 11.4 years there occurs a growth greater than normal, lasting a year or so, also that about midway between these years of "peak" growth there is frequently another year or two of "peak" growth. I do not intend discussing this phenomenon now, further than to say that he erred somewhat as to the 11.4-year interval between "peaks." To be exact it averages 11.21 years, corresponding with the sunspot peak caused by the effect of Jupiter's magnetic field, which attains its maximum when Jupiter's north magnetic pole points most nearly sunward.

Both Huntington and Ricard have shown that sunspots produce barometric changes, and it is inferable that the polarity of the spots determines the nature of these changes. Hale has shown that about midway between the so-called 11-year sunspot "peaks," the new series of sunspots (starting in high latitudes) has a polarity that is the reverse of that of the old series in each hemisphere. By combining these facts I inferred that there should be an alternate 11.2-year weather cycle at least in some parts of the earth, and it should show great persistency. This inference was abundantly confirmed by the data relating to the growth of Arizona pines (as shown in my article above mentioned), and it is amazingly confirmed by the sequoia tree growth records, which run back six times as far as those of the Arizona pines.

In checking my investigation, let the reader start with the Jupiter sunspot peak of July, 1917 (or 1917.6) and calculate the dates of preceding Jupiter maxima by assuming a regular cycle of 11.21 yrs. This will bring a Jupiter peak in August of the first year of the Christian era (0.7 A. D.), and another in Feb. 1221 B. C. (1221.2 B. C.). Since tree rings show only annual growth, and since hair splitting is not called for, take the nearest year preceding a Jupiter peak date, and regard it as the first year of an 11-year period. It will be necessary either to have a 12-year period every 55 years, or to skip a year; and since it is immaterial which is done, I have skipped a year at intervals, as indicated in Table I.

In considering whether an 11-year period is wet or dry, find the mean of the tree growth for the two 11-year periods on each side of the 11-year period under consideration. If that mean of the two periods exceeds the growth during the period under consideration, then the period under consideration is relatively dry; and if conversely, it is wet.

Between 1221 B. C. and 1906 A. D. there are 279 periods of 11.21 years. Of these periods only 52 depart from a regular alternation of wet and dry periods; and 10 of the 52 are turning points where reversals occur in the alternating series. (See Table I.) By this I mean that either two wet or two dry periods occur in sequence, followed by a renewal of the alternate wet and dry periods. The following are the initial years of each of these 10 reversal or turning points in sequoia tree growth.

The second column of Table II shows the years between successive reversals of the 11.2-year cycles. It is noteworthy that there was one span of 953 years in which alternate wet and dry periods (11.21 yr.) occurred with only an occasional interruption, or failure to agree with the alternating wet and dry sequence. Such interruptions were probably caused by an unusually strong magnetic effect due to some planet. In fact, during this span of 953 years there were 85 periods of 11 years, and of these only 13 departed from the alternate wet and dry sequence. In every one of these 13 instances the departure was toward increased rainfall, thus producing three successive wet periods.

Of the 42 breaks of this sort during the 279 periods of 11 years, 34 were such as to cause three wet periods to occur in sequence.

I believe that the 10 reversal points in Table II were due to 10 changes in the preponderance of sunspots in the northern over those in the southern hemisphere; and that these changes depend upon the positions of certain planets relative to the plane of the sun's equator.

It is noteworthy that the lengths of two of these spans are almost 280 years. This may indicate the effect of a planet whose orbital period is about 560 years.

Unless the mathematical laws of probabilities are invoked, the full significance of an accord between theory and fact is rarely appreciated. In this case the result of a probability calculation is quite amazing. Thus, what is the probability that in 237 out of 279 periods an alternate wet and dry sequence would occur by accident?

Applying the "binomial formula"

Table I—Alternate Wet and Dry Periods (11.2 Years) in California as Shown by Sequoia Rings, Back to 1220 B. C. (See Foot Note)

11-Yr. Period A. D.	Average Annual Thickness of Rings in Millimeters	Relative Wetness	
1895-05	0.96	Dry	
1884-94	1.11	Wet	
1873-83	.99	Wet	(Failure to agree)
1862-72	.81	Wet	(Reversal of cycle)
1851-61	.85	Wet	
1839-49	.82	Dry	
1828-38	.82	Wet	
1817-27	.85	Dry	
1806-16	.90	Wet	
1794-04	.98	Wet	(Failure to agree)
1783-93	.95	Wet	
1772-82	.89	Dry	
1761-71	1.09	Wet	
1749-59	.91	Dry	
1738-48	.94	Wet	
1727-37	.87	Dry	
1716-26	.81	Wet	
1704-14	.75	Dry	
1693-03	.73	Dry	(Failure to agree)
1682-92	.75	Dry	
1671-81	.86	Wet	
1660-70	.80	Dry	(Reversal of cycle)
1649-59	.76	Dry	
1638-48	1.01	Wet	
1627-37	.82	Dry	
1616-26	.90	Wet	
1604-14	.88	Dry	
1593-03	.80	Dry	(Failure to agree)
1582-92	.74	Dry	
1571-81	.59	Dry	(Failure to agree)
1560-70	.83	Dry	
1548-58	.87	Wet	
1537-47	.93	Wet	(Failure to agree)
1526-36	.90	Wet	
1515-25	.93	Dry	
1504-14	.98	Wet	
1492-02	.86	Dry	
1481-91	.89	Wet	
1470-80	.74	Dry	
1459-69	.76	Wet	
1447-57	.73	Dry	
1436-46	.79	Wet	
1425-35	.84	Dry	
1414-24	1.12	Wet	
1403-13	.84	Dry	
1391-01	.93	Wet	(Reversal of cycle)
1379-89	1.08	Wet	
1368-78	1.05	Dry	
1357-67	1.07	Wet	
1346-56	.90	Dry	
1335-45	1.15	Wet	
1323-33	1.16	Wet	(Failure to agree)
1312-22	1.13	Wet	
1301-11	.85	Dry	
1290-00	.87	Wet	
1278-88	.86	Dry	
1267-77	.91	Wet	
1256-66	.85	Dry	
1245-55	.77	Dry	(Failure to agree)
1234-44	.76	Dry	
1222-32	.86	Wet	
1211-21	.90	Dry	
1200-10	.96	Wet	
1189-99	1.00	Wet	(Failure to agree)
1178-88	.93	Wet	
1166-76	.88	Dry	
1155-65	.86	Wet	
1144-55	.83	Dry	
1133-43	.97	Wet	
1121-31	.89	Dry	
1110-20	1.08	Wet	(Reversal of cycle)
1099-09	.95	Wet	
1088-98	.91	Dry	
1076-86	1.08	Wet	

11-Yr. Period A. D.	Average Annual Thickness of Rings in Millimeters	Relative Wetness	
1065-75	1.16	Wet	(Failure to agree)
1054-64	.84	Wet	
1043-53	.95	Dry	
1032-42	1.13	Wet	
1020-30	1.34	Wet	(Failure to agree)
1009-19	1.35	Wet	
998-08	1.37	Wet	(Failure to agree)
987-97	1.26	Wet	
975-85	.99	Dry	
964-74	1.16	Wet	
953-63	.93	Dry	
942-52	1.08	Wet	(Reversal of cycle)
931-41	1.07	Wet	
919-29	1.06	Dry	
908-18	1.08	Wet	
897-07	1.12	Dry	
886-96	1.19	Wet	
875-85	1.18	Wet	(Failure to agree)
863-73	1.04	Wet	
852-62	1.09	Dry	
841-51	1.15	Wet	
830-40	1.20	Wet	(Failure to agree)
819-29	1.12	Wet	
807-17	1.05	Dry	
796-06	1.14	Wet	
785-95	1.11	Dry	
774-84	1.37	Wet	
763-73	1.07	Dry	
751-61	.99	Dry	(Failure to agree)
740-50	1.22	Dry	(Failure to agree)
729-39	1.31	Wet	
718-28	1.04	Dry	
707-17	1.18	Wet	
695-05	1.29	Wet	(Failure to agree)
684-94	1.33	Wet	
673-83	1.36	Dry	
662-72	1.50	Wet	
651-61	1.32	Dry	
639-49	1.32	Wet	
628-38	1.32	Dry	
617-27	1.51	Wet	(Reversal of cycle)
606-16	1.33	Wet	
594-04	1.11	Dry	
583-93	1.06	Wet	
572-82	1.00	Dry	
561-71	1.15	Wet	
550-60	.94	Dry	
538-48	1.02	Wet	
527-37	1.24	Wet	(Failure to agree)
516-26	1.21	Wet	
505-15	1.57	Wet	(Failure to agree)
494-04	1.70	Wet	
482-92	1.64	Dry	
471-81	1.48	Wet	
460-70	1.33	Dry	
449-59	1.45	Wet	
437-47	1.76	Wet	(Failure to agree)
426-36	1.96	Wet	
415-25	1.91	Wet	(Failure to agree)
404-14	1.66	Wet	
393-03	1.36	Dry	
381-91	1.64	Wet	
370-80	1.42	Wet	(Failure to agree)
359-69	1.04	Wet	
348-58	.87	Dry	
337-47	.75	Dry	(Failure to agree)
325-35	.81	Dry	
314-24	.91	Wet	
303-13	.86	Dry	
292-02	1.04	Wet	(Reversal of cycle)
280-90	.96	Wet	
269-79	.85	Dry	
258-68	.96	Wet	
247-57	.91	Dry	
236-46	.93	Wet	
224-34	.99	Dry	
213-23	1.14	Wet	
202-12	1.42	Wet	(Failure to agree)
191-01	1.40	Wet	
180-90	.98	Dry	(Reversal of cycle)
168-78	.86	Dry	
157-67	1.02	Wet	
146-56	1.04	Dry	
135-45	1.06	Wet	
124-34	.99	Dry	
112-22	1.35	Wet	
101-11	1.06	Dry	
90-00	1.25	Wet	
79-89	1.48	Wet	(Failure to agree)
68-78	1.30	Wet	
56-66	1.21	Dry	
45-55	1.56	Wet	
34-44	1.90	Wet	(Failure to agree)
23-33	1.91	Wet	
12-22	1.47	Dry	
0-10	1.65	Wet	
B. C.			
1-11	1.39	Dry	
12-22	1.47	Wet	
23-33	1.61	Wet	(Failure to agree)
35-45	1.63	Wet	
46-56	1.64	Dry	
57-67	2.16	Wet	(Reversal of cycle)
68-78	2.18	Wet	
79-89	1.86	Dry	
90-00	1.84	Wet	
102-12	2.41	Wet	(Failure to agree)
113-23	2.31	Wet	
124-34	2.20	Dry	
135-45	2.31	Wet	
147-57	2.25	Wet	(Failure to agree)
158-68	1.97	Wet	
169-79	2.28	Dry	
180-90	2.60	Wet	
191-01	2.36	Dry	
203-13	2.25	Wet	
214-24	1.41	Dry	
225-35	1.20	Wet	
236-46	1.43	Dry	
247-57	2.45	Wet	
259-69	2.64	Dry	(From 270 to 274 the average yearly growth was 3.56)
270-80	.73	Wet	(A different group of trees starts here)
281-91	.76	Dry	
292-02	.84	Wet	
304-14	.86	Wet	(Failure to agree)
315-25	.77	Wet	
326-36	.69	Dry	
337-47	.72	Wet	
349-59	.78	Dry	
360-70	.90	Wet	
371-81	.94	Wet	(Failure to agree)
382-92	.77	Wet	
393-03	.75	Dry	
405-15	.84	Wet	
416-26	.73	Dry	
427-37	.93	Wet	
438-48	.85	Wet	(Failure to agree)
449-59	.75	Wet	
461-71	.93	Wet	(Failure to agree)
472-82	1.06	Wet	
483-93	1.01	Dry	
494-04	1.04	Wet	
505-15	.93	Dry	
517-27	.86	Wet	
528-38	.89	Dry	
539-49	1.23	Wet	
550-60	.95	Dry	
561-71	.86	Wet	
573-83	.77	Dry	
584-94	.92	Wet	
595-05	1.01	Dry	
606-16	1.09	Wet	
617-27	1.18	Wet	(Failure to agree)
629-39	1.12	Wet	
640-50	1.08	Dry	
651-61	1.21	Wet	
662-72	1.34	Wet	(Failure to agree)
674-84	1.34	Wet	
685-95	1.64	Wet	(Failure to agree)
696-06	1.48	Wet	
707-17	1.34	Dry	
718-28	1.35	Wet	
730-40	1.34	Wet	(Failure to agree)
741-51	1.32	Wet	
752-62	1.21	Wet	(Failure to agree)
763-73	1.09	Wet	
774-84	1.08	Dry	
786-96	1.16	Wet	
797-07	1.12	Dry	
808-18	1.08	Wet	
819-29	1.34	Dry	
830-40	1.51	Wet	
842-52	1.17	Dry	
853-63	1.26	Wet	
864-74	1.66	Dry	
875-85	2.21	Wet	
886-96	2.14	Wet	(Failure to agree)
898-08	1.95	Wet	
909-19	1.68	Dry	
920-30	2.21	Wet	
931-41	1.71	Dry	
943-53	1.37	Dry	(Failure to agree)
954-64	1.17	Dry	
965-75	1.24	Wet	
976-86	1.20	Dry	
987-97	1.30	Wet	
999-09	1.30	Dry	
1010-20	1.40	Wet	(Reversal of cycle)
1021-31	1.60	Wet	
1032-42	1.39	Dry	
1043-53	1.44	Wet	
1055-65	1.35	Dry	
1066-76	1.95	Wet	
1077-87	1.75	Dry	
1088-98	2.07	Wet	
1099-09	2.07	Dry	
1111-21	2.19	Wet	
1122-32	2.69	Wet	(Failure to agree)
1133-43	2.90	Wet	
1144-54	2.78	Dry	
1156-66	3.00	Wet	
1167-77	3.59	Wet	(Failure to agree)
1178-88	3.67	Wet	
1189-99	3.31	Dry	
1200-10	3.28	Wet	
1211-20	3.17	Dry	

Note: An 11-year period is "wet" if its average annual ring thickness is greater than the mean ring thickness of the preceding and following 11-year periods; and conversely as to "dryness."

Table II—Dates of Reversal of the 11.2-Year Cycles

Date of Reversal	Years Between Reversals
1862 A. D.	202
1660 A. D.	279
1391 A. D.	281
1110 A. D.	168
942 A. D.	325
617 A. D.	325
292 A. D.	112
180 A. D.	237
57 B. C.	953
1010 B. C.	

Note: From 1010 B. C. to 57 B. C. there were 85 periods of 11.2 years in which there was an alternation of wet and dry periods in every instance except 13, and those 13 periods were wet whereas they would have been dry had the alternating sequence been unbroken. Then the 11-year period beginning 57 B. C. introduced a reversal of alternation of wet and dry periods, as shown in Table I.

(Fry's "Probability and Its Engineering Uses," p. 63) we find that there is only one chance in 6.8×10^{33} that it is accidental. Since it is more impressive to express this ratio without the use of exponents, let us do so; it is one in 6,800,000,000,000,000,000,000,000,000,000,000, or nearly seven trillion quadrillion. Even if we consider only the series of 11-year periods from 1010 B. C. to 57 B. C. we have 85 periods in which only 13 breaks in the sequence occur. This gives for the "binomial formula" m=84 and n=13, from which we deduce that this could have occurred accidentally only 1 time in 17 billion.

No relationship between sunspots and weather has hitherto been so conclusively established by an appeal to the laws of probabilities.

Incidentally two important facts are also established: First, that the so-called 11-year sunspot cycle can not differ much from 11.21 years, for if it did, the alternation of wet and dry periods of the assumed 11.21 years would have ceased long before 1220 B. C. had been reached. Second, it becomes evident that Hale's periodic change in the polarity of sunspots is not an ephemeral affair, but has existed for at least 3,100 years.

In a later article I will show that the frequent alternation of wet and dry years is due to the existence on Jupiter of 12 permanent magnetic whirls, similar to the 12 molten whirls which, by the air of topography I have located in the earth. The centers of those molten whirls were given in an article in "Engineering and Contracting," October, 1929, p. 425. The location of the center of whirl C was incorrectly given there; it is 40° N., 132.5° E., being almost in the center of the Sea of Japan. This particular molten whirl explains not only the circular form of that sea, but the persisting volcanic activity of that region.

Corresponding to these 12 molten whirl centers, and not far from them, are the centers of 12 permanent anticyclones, thus showing that both the molten interior of the earth and the air above the earth are similarly energized.

A discussion of the 12 molten whirls will appear in "Engineering and Contracting," together with data that prove

the existence of each of them. The laws of probability will be used to show that the existence of arc-shaped mountain ranges, arc-shaped chains of islands, etc., around these 12 centers is highly improbable unless permanent whirls have existed ab initio in the earth's molten interior. Since free electrons under the influence of magnetic fields acquire rotary motion about lines of magnetic force, it is clear that the molten whirls in the earth are electromagnetic phenomena. The same is true of air whirls, from the smallest to the largest, from the most enduring to the most ephemeral.

Aerial Surveys for Reservoir Project

How They Were Used to Aid Ground Surveys for Swift Power Reservoir in Massachusetts

THE Metropolitan District Water Supply Commission of Boston, Mass., has had considerable experience with aerial photography in connection with a projected new water supply development. In a recent discussion before the Boston Society of Civil Engineers, N. LeRoy Hammond, Division Engineer of the Commission, described how the aerial surveys were used for the proposed Swift River Reservoir. The notes following are taken from his discussion.

The contract with Fairchild Aerial Surveys, Inc., was for the aerial survey of the area to be affected by the proposed Swift River Reservoir, and was in preparation of extensive ground surveys of that area.

The science of aerial photography is relatively new, and while many engineers have been interested casually and are always anxious to view the aerial photographs, yet they are inclined to be somewhat skeptical as to their practical value, particularly where one user will dwell on the accuracy of results, while another will claim that but little accuracy can be obtained. From the experience in the Swift River Valley the aerial survey is a valuable asset to the work of the field engineer.

What the Contract Covered.—The contract called for the photographing of some 100 square miles of area. The Swift River Valley is characterized by a series of high ridges from three to four miles apart, running generally in a northerly and southerly direction. Scattered through the floor of the valley are also numerous hills rising sharply 500 to 700 ft. above the river level. For the purpose of photography, the natural course for the flight of aircraft was in a northerly and southerly direction along the axes of the various valleys. With the contract calling for an overlap of 50 per cent there resulted a large number of contact prints of the entire area. The photographs were taken at a flight elevation of between 10,000 and 12,000 ft. above sea level, which resulted in contact prints 7 by 9 in., with a scale of approximately 1,100 ft. to the inch. The contract also provided for enlargements to a scale of 1 in. equals 400 ft., with control data for such enlargement to be supplied by the engineers of the commission. Aside from the Massachusetts topographic maps, there was little data available for proper control because actual ground surveys had advanced but slightly when the aerial photographs were taken. Furthermore, as the object of aerial photography was to aid the ground survey, it became necessary to secure control data within the shortest possible time.

Determining Enlargement Ratios.—An attempt was made to scale from the United States topographic maps the distances between intersections of highways to compare with the photograph of the same highways shown on the contact prints, but as many prints showed but small stretches of such highways this method was found to be impracticable. Finally, distances from definite points on each contact print, such as known houses or other outstanding features, were actually measured by roughly dragging a long chain between these points, generally along the highways. The scale of various sections of each contact print was then approximately determined and a ratio for enlargement evolved. Considerable variation of scale of different portions of each contact print were found, due largely to differences of from 500 to 600 ft. in ground elevation with resultant camera distortion. The contact prints were particularly clear, and it was decided that in general little would be gained by having enlargements, and consequently only a few of the contact prints were enlarged by the photographic process. Had the area been more uniformly of the same elevation, it is probably that enlargement ratios would have been more easily determined and an actual aid would have resulted in having all photographs to the same scale.

Many Uses of Contact Prints.—The uses of the contact prints have been many. The area which was photographed will ultimately be acquired by purchase or otherwise, and involves a considerable task in the examination of title of real estate holdings. In the case of three of the towns in the valley approximate real estate maps were made by the use of the contact prints. Each print was carefully studied and every indication of a property line was pantographed to a skeleton map of the town. The resultant plot was then taken into the field in company with an assessor of the town, and actual known property lines were designated as such on the plot. Owners' names were inserted as encountered. Thus a somewhat crude map of each town was developed generally by two men in about two weeks. This gave a working map for a systematic search of real estate titles by title examiners, and without doubt has been of considerable value in this work.

As the ground survey of topographical features and real estate surveys have progressed, constant use has been made of the contact prints in the checking of plots of these surveys. We have all had the experience of plotting field notes with an uncertainty of the interpretation of proper connection between points located. With the contact print at hand an immediate check on such plotting can be made, thus facilitating the proper final execution of the map.

Use in Real Estate Surveys.—Party chiefs have taken the prints into the field, and by questioning local residents have gained a great deal of information as to the exact location of property lines. In a wooded country it often happens that even owners are uncertain as to their exact lines. A careful inspection of good contact prints will indicate a line of difference of timber growth of but few years, whereas on the ground no difference in growth may be observed. By calculating the azimuth of these indicated lines from lines of known location, the field party can generally, in a relatively short time, determine a somewhat difficult property line and corner. Without the data shown on the contact print similar locations might take several days of searching.

Use in Analysis of Real Estates Deeds.—The contact prints have also been of considerable assistance in the analysis of real estates deeds. In one instance a lumber operating company had released their holding by option. The tract of land had originally been made up of three parcels. Upon the checking of the deeds which conveyed these parcels there was one which could not be made to fit into the larger tract. It had been carefully drawn by metes and bounds, and but little could be found of its history. A close examination of contact prints was made in order to see if any parcel might be observed which would fit the troublesome deed. At a considerable distance away from the large tract to be conveyed was found a picture of a plot of ground which appeared to fit exactly. A field party was sent out to make a ground survey of the new area, and it was found that it did cover the deed in question. It finally developed that an early owner had held deeds for five parcels of land, one of which was included in the tract of the lumber company, and another in the parcel surveyed. It appeared that the wrong deed had been copied and unintentionally a parcel had been conveyed with no connection to the tract desired.

Temporary Suspension Bridge Carries 36-in. Pipe Line over Landslide

Emergency Measure Called for When Highway Cut Causes Slide, Endangering San Francisco's Water Supply—Work Completed in 17 Days with No Interruption of Service

By C. A. LAUENSTEIN
Assistant Engineer, Spring Valley Water Co.

CONSTRUCTION work by the state of California on the new Bay Shore Highway, from San Francisco to San Mateo, caused renewed movement of an old landslide crossed by a trestle supporting a 36-in. pipe line of the Spring Valley Water Co. In order to prevent serious damage to the line a 170-ft. suspension bridge was built as an emergency measure to span the slide. Seventeen days were required to complete the work and transfer the load from the existing trestle. During this time service was maintained without interruption.

The pipe line crossed the slide on a trestle about 300 ft. uphill from the highway. This trestle was about 130 ft. long and 10 ft. high and had bents spaced at 14-ft. intervals. It was built twenty-five or thirty years ago when movements of the slide first became evident. At that time two precautions were taken to prevent damage to the pipe line and trestle from further movement of the landslide: (1) the pipe line was equipped with lead band joints at about 25-ft. intervals and (2) the pipe line was supported on two lines of girders, each span of which was capable of carrying the load across two trestle spans, or a total of 28 ft. These girders were built up of three 8x12-in. timbers bolted together, forming an 8x36-in. member.

Plans for the new highway called for a heavy sidehill cut across the toe of this landslide. In order to prevent movement of the slide a heavy masonry retaining wall was designed. Before the wall had been completed, movement of the slide began. This was evidenced by a slight sag in the pipe line and the appearance of cracks between the retaining wall and the trestle. The main crack, which opened up about ¼ in., paralleled the trestle at the downhill edge of the bents. In order to observe further movement of the slide, stakes were driven 1 ft. on each side of the main crack and measurements taken several times daily.

Believing that further movement might occur as a result of winter rains or before the retaining wall could take the load, the company's engineers decided that some method must be devised to insure against serious damage to the 36-in. pipe line, which is a portion of a 44-in. main supply line. Such an occurrence would cut off about 50 per cent of the water conveyed into San Francisco. The only safe manner to support the pipe across the slide seemed to be a suspension bridge. In order to finish the job before the rainy season a time limit of three weeks was set.

Field work started within two days after the slide started. No time was taken in the office to investigate the proper locations for the towers or anchors. These were located according to field conditions only. The towers were spaced 170 ft. apart and the anchors located so that the slopes of the backstays would be equal. Final results showed less than 2 deg. difference in these slopes.

As brought to the office, the problem was to design a suspension bridge to fit the above-mentioned conditions, to use only materials that could be obtained without delay and to utilize the existing trestle girders as stiffeners. These were found to be in good condition and sufficiently cross-braced to act as sway-bracing. The first thing done was to make a rough analysis, using a uniform load on the 170-ft. span, to obtain an idea of the magnitude of the forces and the dimensions of the various members.

The anchors were designed to contain enough concrete to have a total weight equal to two times the cable pull and have an area sufficient to limit the earth pressure to 2,000 lb. per square foot. Each cable anchor required about 13 cu. yd. of concrete. Fortunately an existing concrete plant was available less than 600 ft. away. For fastening each cable to its anchor two 1x6-in. steel anchor bars, 20 ft. long, were embedded in the concrete. One end of each of these bars, containing an eye, was left projecting from the concrete.

Thirty-foot towers were finally selected. This height allowed for a 30-ft. total sag and made it possible to use 2-in. cable. Larger cables could not be obtained for immediate delivery. Double A-frame towers built up of four 14x14-in. timbers were designed. These were supported upon concrete piers. On top of the towers special cast-steel cable saddles were

Work on Retaining Wall and Suspension Bridge After Start of Slide. The Old Trestle Is Carrying the Load. The Highway Is in the Foreground

Bridge Complete; Scaffolding Not Removed. The Double Hanger in the Foreground Was Needed at This Girder Splice Only

placed to support the cables and eliminate sharp bends.

The total time required to pour the concrete anchors and piers and to erect the towers was about ten days. During this time the cable and the suspender connection were being designed, detailed and purchased.

From anchor to anchor the cable length was estimated as 370 ft. In ordering, however, the length was reduced 30 ft. to allow 15 ft. at each end for a set of blocks to pull the cable to the required tension. Eight strands of ⅞-in. cable wound around special sheave wheels were used for this purpose. At the anchor end the sheaves were placed around a 4¼-in. pin which passed through the eyes of the anchor bars. A special clevis was designed to connect with a 2-in. standard open socket at the end of the main cable. This consisted of two 12x24x1-in. plates set 10 in. apart, through which two 4-in. pins were passed. One pin passed through the sheaves and the other through the socket. The pipe was supported by hangers suspended from the 2-in. cables. Each of these hangers, which were spaced at 14-ft. intervals, consisted of a ⅛-in. cable fastened with clips at the lower end to the eye end of a 1¼-in. by 4-ft. threaded rod. These rods passed through 10x10-in. timbers upon which the 8x36-in. girders rested. For fastening these hangers to the main cable an inverted cable clamp was used. This was equipped with a special casting that allowed the clamp to be tightened on the cable and leave a space for the hanger and thimble.

In order to have a final sag at the center of 30 ft. it was necessary to compute the actual sag caused by loading. Rough calculations showed this to be 2 ft. The cable was therefore hung with a center sag of 28 ft. To eliminate the sag in the backstays during erection, they were supported every 30 ft. by A-frames. Transferring of the load was accomplished by screwing up on pairs of hangers in successive short rises. These rises were computed as proportional parts of the center sag. The final center sag proved to be 1 ft. greater than computed; this was probably caused by stretch in the cable and roughness of the calculations. In the meantime more accurate calculations were being made, and final adjustments were made to conform with these. Longer hanger rods were used at the six center supports and ⅞-in. cable was eliminated here, the rods being fastened directly to the cable clamp. As finally adjusted the load was uniformly distributed along the cable. The slight sag in the pipe caused by the slide was taken up to make an even grade. When loaded the cable stress was only 52,000 lb. as against a safe strength of 60,000 lb., this difference resulting from the fact that only 126 ft. of 170-ft. span, was actually loaded, whereas the design was based on a uniform load for the entire span.

During construction, observation on the main crack showed practically no movement of the slide. Thirteen days after the load had been transferred, however, the slide became active again. The total settlement of the old trestle was 10 ft., most of which occurred within 30 minutes. The cost of the construction was about $17,000.

The work was done by construction forces of the Spring Valley Water Co., in charge of T. W. Espy, assistant chief engineer. Design details were worked out by the writer, under supervision of I. E. Flaa, office engineer.

Finished Bridge Supporting Pipe. Note Subsidence of Old Trestle and Cracks in Ground. Highway Is in Left Foreground

Some Notes on Water Works Operation

ONE of the most important features of the 1929 convention of the American Water Works Association was the session devoted to "Round Table" discussion by the superintendents and other officials. At these sessions much useful information was brought out regarding the practices in various cities. An interesting summary of these practices based on the discussions was given by J. Walter Ackerman, City Manager, Watertown, N. Y. It is reprinted here from the November Journal of the association.

Fire Hydrants Broken by Motor Vehicles.—Due to fast moving traffic with heavily loaded trucks, collisions with hydrants are bound to occur and usually result disastrously so far as the hydrant is concerned. Some times the truck or automobile goes scot free and the driver, without a conscience, leaves the place without reporting same. The question here is, "What is the remedy?" Several places report the adoption in the busiest districts of the flush hydrant, others advocate moving the hydrant away from the curb and others the placing of protective devices around the hydrant.

Meter Reading.—"In a metered system, what happens when the meter reader is unable to gain entrance to the building." In general, there is a return of the meter reader to the premises on a pick-up excursion to see if he cannot locate the family at home. If not, a return post-card is usually mailed to them with the request that they mark upon the form printed on the card the location of the dials, or if it is a straight reading register, the exact figures showing in the opening.

Depreciation Reserves.—"As to the percentage of cost used for depreciation on cast iron pipe, water station equipment, buildings, concrete floor and graveled roofs." It would appear from a review of the figures presented on this that the depreciation charges are made fairly low. As cast iron pipe is one of the principal items of expense, an examination of replies shows that it runs from one to a maximum of about 2.4 per cent, but, in general, it is evident from the reports that 1½ per cent would be about the average depreciation charge against Class "B" cast iron distribution pipe. With the other items, they vary within wide limits from 2 up to a maximum of 25 per cent for fixed assets.

Consumer's Good Will.—A practice that is altogether too uncommon is that of making a personal contact with the new consumer. One city presents a form letter which is sent out by the company to every new consumer who takes water. This creates a kindly feeling and establishes a relationship that may later help the superintendent out of any difficulty that may involve a new customer.

Collecting Water Bills.—A new method of collecting water bills is reported. That is, a city rendering quarterly bills usually has three districts, and they are sent out each month all at one time with a certain number of days allowed for payment without penalty. In the larger cities this results in over-crowding the treasurer's office on the last days for payment. To obviate that each district has sub-districts in which the date of payment is varied for every one of the sub-districts one or two days. In terms of the electrical industry that means that they have a more uniform load factor so far as collecting bills is concerned.

Shutting Off Water.—One waterworks has found a new reason for shutting off water. In a case in New Jersey it was ruled by the court that where a dog on the premises keeps the meter reader from reading the meter, the water company is justified in shutting off the service. The court said, "If the complainant (water consumer) refuses or neglects to maintain a condition at his residence admitting of regular meter readings, the company will be justified in discontinuing service and refusing to resume the supply until such condition is corrected."

Hydrant Rentals.—One of the important questions that is often asked is, "What rental do you charge the city for fire hydrants?" Unfortunately, of course, many of the municipally owned plants make no charge in the general tax levy for fire hydrant use or for general public fire protection. If this is a property benefit it should be charged against the general levy.

The maintenance of the fire department with its apparatus, building and equipment is all a general property tax and justly so, but this is but a part of the general fire protection scheme. Without the waterworks with its hydrants, its enlarged mains and works, the personnel of the fire department would be unable to render any service. There should always be a charge, therefore, in the general city tax levy for the use of the fire hydrants and the mains, etc. The general question is, how much or in what manner shall the amount be computed. From the replies appended and from the opinion of those who have helped to make our manual of practice a model and guide, it seems to point directly to two factors; one, the number of standard hydrants and the other the inch feet of mains. While the amounts may vary the principle is the same. The gross amount allocated to public fire protection should be determined. The rates should then be proportioned to the amount of inch feet of mains and the hydrants so as to yield the required sum.

Waterworks Forms and Their Use.—The systematizing of all sorts of control accounting for widely different purposes has developed immensely within a decade. In waterworks operation, while progress has been made to some extent, the same advance has not been made that we find in other lines of business activities. Such articles as we find on the development of different systems of bookkeeping and detail will be of great advantage for study in order that accounting control and information may be made available.

Tapping Mains.—"What is the practice with regard to tapping of mains for various size services from ¾ to 3 in.?" It would appear that the trend of practice is to use a wet tapping machine from ¾ to 1 in. and with larger sizes to cut in a tee or use a tapping sleeve and valve.

Frozen Service Pipes.—In the colder climates, the question of frozen service pipes is always a bothersome matter because the customer who is unfortunate enough thinks he is being discriminated if he finds that his service is frozen and that of his neighbor is still free from the frost. Of course, the reason for frozen services is that they are laid in too shallow trenches and modern snow removal practice makes for greater exposure. In our northern latitudes like Watertown we cover mains and services at least 5 ft. This does not always protect us, however, and during some winters the extreme cold will render large numbers of services impossible of use without thawing. The best general practice at the present time is in the use of one of the small machines operating under its own power and developing current of a proper strength to thaw out the services running into the houses. This is much better practice than the old method of hot water and a pipe line inside of the service pipe. Unless the pipe was laid in exact line or level it was usually difficult to secure proper results with the hot water, whereas, with electricity, it takes but a few minutes to thaw a frozen pipe sufficient to start the water.

The freezing of the service pipe sometimes involves the meter as well. Practice dictates that the necessary repair in such a case should be borne by the user or owner of the building.

Meter Setting and Ownership.—Pursuing the meter subject further, not much is found as to practice of owning and setting meters. However, it is generally conceded that ownership should be vested in the waterworks and the waterworks with its own employees should make the settings, first, because of their proper interest in determining the best location in complicated cases and to be sure that all water used should pass through same, and secondly, it can be done at a much lower figure than by plumbers. In a

recent experience in my own city, the cost of installing about 2,000 ⅝-in. meters averaged $1.90 per meter, covering all expenses therefore, as follows:

Fittings, including labor cost of cutting threads on piping	$0.67
Labor cost, testing and sealing meters	.09
Labor cost installing, including time of foreman, assigning work and checking, material and installation	1.14
Total	$1.90

The only item not charged for was use of service truck for foreman. The wages paid the general foreman were 60 cents. Each meter setter was paid 55 cents and each meter setter's helper was paid 50 cents. The average number of meters set each day by each crew of two men was 7.6 in 8 hours.

We call our waterworks a "utility," and first of all it should be utilitarian. Unfortunately, in too many cases it never gets beyond that point, as in general the funds available are all needed for the basic requirements. There seems to be an increased interest in the possible aesthetic values inherent in the building of, or the later development of, the works. Landscaping of the grounds can be accomplished with small outlay, keeping storehouses and yards in a neat condition. All these factors tend to impress upon the public that this quality extends to the product as well. In some places where it is necessary to have elevated water towers they should be made artistic to conform with the surroundings.

The interior of filter plants and pumping stations should be kept in the most clean and orderly way. Even the much criticised polished brass has a wholesome effect, not only on the public but on employees, for in some instances it is almost necessary to provide some such detail to keep an employee busy.

Well Drillers to Meet.—The American Association of Water Well Drillers will hold its convention in conjunction with the Minnesota Well Drillers' Association, at the Twin Cities, Feb. 4, 5, and 6, 1930. Delegates from eight states will be present. An attendance of about 400 is expected. Meetings will be held in the Engineering Building, University Farm, Midway, St. Paul, Minn. The National Council, including representatives of each state drillers' association, engineers, geologists, manufacturers, the National Research Council, and the U. S. Geological Survey, will consider such questions as drilling standards and ethics, specifications for wells, equipment standards, etc. Drillers, engineers, and others interested in water supply are invited to attend the open meetings of the convention. M. J. Spencer, Granada, Minn., is president.

Chloro-Phenol Tastes in Water Supplies from Ohio River

In connection with studies of stream pollution, it has been found by the U. S. Public Health Service that for several years past, and particularly since the war, tastes and odors of such a nature as to identify them with the presence of phenols and allied substances have been experienced, with varying frequencies, in the water supplies of cities located on the inland waterway systems of the middle western and eastern portions of the United States. Tastes of a similar nature have appeared in water supplies located in other areas, both of this country and of Europe. In no instance, however, has this difficulty been more serious or affected larger groups of population than it has in the area adjoining and tributary to the upper portion of the Ohio River, which drains a highly industrialized region serving as a center of the coal, steel, and allied industries.

A search for the specific causes of the tastes and odors above described revealed the fact that during and since the war period the coke-producing industry has been abandoning the use of the older "beehive" ovens for burning coke and has been sustituting for them modern by-product plants, from which valuable substances are recovered from the gases which formerly went to waste in the atmosphere. The residues from some of these recovery processes, notably those concerned with the manufacture of benzol and ammonia, have been found to contain very considerable amounts of tar, phenols, creosols, creosotes, and similar substances, which, when discharged into sources of water supplies, produce characteristic "medicinal" tastes and odors in them. Although other classes of wastes, notably those derived from producer-gas plants, have been found to contain phenols and similar taste-producing substances, the total amounts of phenols resulting from the operation of coke by-product plants are so much greater than those produced by any other single industry, and their production takes place in such highly concentrated areas, that a large share of the responsibility for the difficulties caused by wastes of this class logically has been attributed to them.

Recent studies by other workers have shown that the oxidation of phenols, which can be accomplished by ordinary biological processes of sewage treatment when phenolic wastes are mixed in proper proportions with sewage, is essentially a biochemical phenomenon, proceeding along definite time-function curves at rates varying closely with the temperature, being greater at higher temperatures, and vice versa. As the behavior of phenols in the Ohio River has been consistent, except in degree, with their reactions to artificial processes of oxidation, it would seem quite logical to infer that the progressive reductions thus observed under natural conditions may be due to a process of natural biochemical oxidation similar, in its general characteristics, to that which proceeds more intensively under artificial conditions.

If the foregoing theory is correct, its lesson is fairly obvious in so far as its application to problems involving the elimination of sources of phenol pollution of water supplies is concerned. In cases in which water supplies are subject to continuous or frequent pollution by phenols, the important sources of such pollution are more likely to be found in the near vicinity of the supply than at any considerable distance. If, however, they are subject only to occasional pollution, occurring more especially during the colder season, or in streams, coincidently with high river stages, the source of the trouble probably is located at a more distant point. In undertaking any general program of remedial measures looking to the relief of phenol pollution of water supplies, located along an entire stream, the maximum immediate benefit of such measures probably will be attained by eliminating, first, all sources of phenol pollution located directly on the stream in question or in the lower reaches of tributaries discharging into the main stream above the points at which the water supplies affected are located. The history of phenol tastes in Ohio River water supplies, both during and following the institution of progressive remedial measures by the bordering states, has afforded an interesting confirmation of the principle stated.

The effectiveness with which the pollution of Ohio River water supplies by phenol wastes has been brought under a large measure of control within the comparatively short period of time intervening since the year 1925, constitutes one of the brightest pages in recent sanitary history. Accomplished, as it has been, without any coercive legislation, but through cooperative effort by the Federal and state governments and the industries concerned, it augurs well for the future solution of some of the larger problems of stream pollution now confronting the nation. Although pollution of the Ohio River system by wastes has not been completely eliminated, as evidenced by occasional "spills" which have occurred during the past year or two, it has been curbed to an extent such as to justify the expectation that in the near future it will cease to be a major problem along this important waterway. A generous measure of credit is due to those whose joint efforts have brought about this fortunate result.

Water Supply for Los Angeles from High Sierras

By WALTER A. GILLETTE

IN former articles on the Colorado River Boulder Dam Project I have questioned the advisability of carrying through such a project at any time, or for some years to come at least. My opinions have been based on general engineering and structural knowledge, aided by a good idea of the topography of the High Sierras.

Recently I made some sketches of the territory drained by six of the large basins, namely, Owens River, Bishop Creek, Owens Lake, Mono Lake, East Walker River and West Walker River, all within the state of California. This study has shown conclusively that a large additional quantity of water can be easily diverted for use in the Metropolitan Water District of Los Angeles.

I have taken my data from several authentic sources, such as the California State Engineers Report, Bulletin No. 5, "Flow in California Streams," and from a bulletin containing papers read last June before the University of Southern California, under the title "Water Papers," and from the report of Los Angeles City Department of Power and Water.

Owens River Basin.—The California Engineers' report shows that the Owens River Basin has 524 square miles drainage area, which produces a mean run-off of 278,000 acre-feet, equal to 281 second-feet, which, based on 5,000 people served per second-foot (the figure used by the Los Angeles City Water engineers as being sufficient for domestic and industrial purposes, but does not include farm irrigation) would supply 1,405,000 people. It is well to state at this point, that as these figures are the mean run-off, that probably not more than 50 per cent of the amount given can be conserved by the use of reservoirs.

Bishop Creek has 446 square miles area, producing 341,500 acre feet, or 468 second feet, supplying 2,340,000 people. Owens Lake has 216 square miles area, producing 83,000 acre feet, supplying 570,000 people, or a total of 863 second feet, which multiplied by 5,000 would serve 4,315,000 people; but, as I stated above, it will hardly be safe to figure on more than half these figures, therefore we get 431 second feet, serving 2,157,000 people, almost all of which can be carried by the existing aqueduct, for its capacity is 400 second feet.

The City Engineer's report shows 540 second feet now available in the local area of the Metropolitan Water District, without the Owens River supply, therefore the local water supply, plus the 400 second feet from the present aqueduct, is 940 second feet, which will serve 4,700,000 people. It is quite apparent that less than half this amount is being used for domestic and industrial purposes, for the present population is only 2,350,000 people.

By a deduction from data published by the Board of Water and Power, I find that about 36 per cent of the Los Angeles aqueduct is being used for irrigation. This would supply a city of 600,000 people.

It is evident that not all of the water in the three basins, in what I will term Owens Valley, is being conserved, which indicates that a large storage reservoir, such as the one proposed at Long Valley, at the head waters of the Owens River, is vitally necessary and should be built at once.

Assuming that the figures of the Los Angeles engineers are correct, it is clear that they show water enough for twice the population now in the Metropolitan Water district without looking further, provided that none of it is used for irrigation or is wasted.

Mono Lake Basin.—However, as we proceed, other interesting developments unfold. Mono Lake Basin shows 166 square miles drainage area, with 215,650 acre-feet run off, being 282 second-feet, one-half of which can be stored and diverted, which will serve 700,000 people. Just beyond Mono Lake we come to the East Walker River Basin, with 411 square miles area, with 312,300 acre-feet run off, or 428 second-feet; one-half can be conserved and will supply 1,075,000 people.

Running parallel to East Walker and a short distance northwest, is the West Fork of Walker River, 450 square miles drainage area, giving a run off of 313,800 acre-feet or 430 second feet, one-half to be conserved can furnish another 1,075,000 people. These figures give us water for 2,850,000 people, which when added to the 4,700,000, makes 7,550,000 people. When will the need arise for that amount of water?

An exceedingly advantageous point about the development of these drainage basins is that they can be developed as the needs demand. My rough estimate is that the six basins enumerated can be developed, including land purchase and damage to small farms, for not to exceed $100,000,000 cost.

After deducting a prorated sum for power not used in pumping water from the total estimated cost of the Colorado River project, there remains about $400,000,000 for developing 1,500 second-feet of water from that source. Bear in mind at all times that after this proposed Colorado River expenditure, the plant will be saddled with a perpetual pumping cost to lift the entire volume used, 1,600 ft. Whereas only a part of the water from Walker River basin need be pumped, and that with a lift not exceeding 1,000 ft.

Ease of Development.—One of the most attractive features of this High Sierra layout, aside from extreme economy as compared with any other, is that each of five units can be developed as needed, which I would place in the following order: (1) develop all water in the Metropolitan Water District, (2) develop all water in the Owens River basin, (3) develop and divert all water in the Mono Lake basin, (4) develop all water in the East Walker River basin, (5) develop all water in the West Walker River basin.

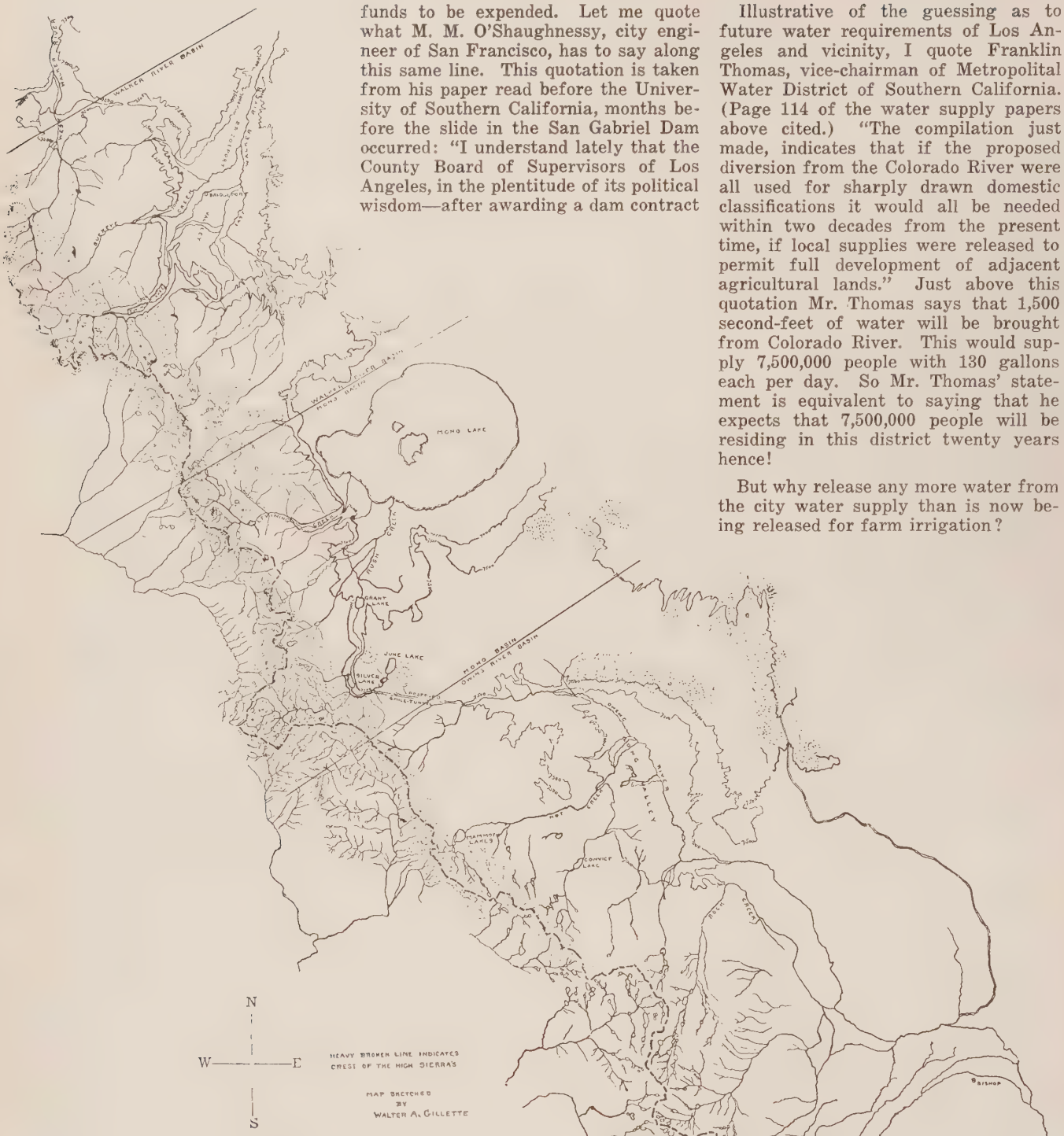
In this entire group there is not a single difficult problem; in fact the whole layout is so simple that no engineer, by its development, could leave much of monument to the glory of his ability. It is perfectly natural that any engineer should wish to be a party to so collosal a construction as the Boulder Dam. Granting the right to any man to be ambitious, I see no reason why the taxpayers should paint any engineers' names in wasted gold on the cliffs of the Colorado River.

Engineers Disagree.—There seems to be no unanimity of opinion among engineers as to the amount of water needed by Los Angeles and vicinity. For example, the Consulting Board, composed of Hill, Lippencott, and Sonnderegger (page 112 of papers read last June, University of Southern California) show 130 gallons per capita per diem for domestic use, plus about 30 gal. for industrial use, total 160 gallons per capita per diem for Los Angeles urban territory.

E. A. Bailey, of the Los Angeles Water and Power Department, allows 5,000 people per second-foot which is equivalent to about 130 gal. per capita per diem. Statistics show that the city of Detroit uses 125 gal. per capita per diem. And the city of Milwaukee uses about 100 gal.; I was going to suggest that must be because of their beer; but it takes water for beer, so that can't be the reason. M. M. O'Shaughnessy, city engineer of San Francisco, who has charge of the Hetch Hetchey water development, estimates 100 gal. per capita per diem, and he states that his city employed several boards of independent engineers to pass on all their problems.

Average Water Consumption.—As I looked up figures on the per capita use of water in American cities I thought at first glance, that the big spread was because of some peculiar locality, yet San Francisco's use of 100 gal. per person daily, shows that such is not the case. So when we see a spread of 60 per cent in the estimated per capita use of water, among engineers of high standing, we are apt to ask ourselves this:

If these engineers do not agree on



Location of Basins in High Sierra Region Capable of Supplying Water Sufficient for 7,500,000 People

funds to be expended. Let me quote what M. M. O'Shaughnessy, city engineer of San Francisco, has to say along this same line. This quotation is taken from his paper read before the University of Southern California, months before the slide in the San Gabriel Dam occurred: "I understand lately that the County Board of Supervisors of Los Angeles, in the plentitude of its political wisdom—after awarding a dam contract —dispensed with the Board of Consulting Engineers who had been employed on the San Gabriel Dam, a work involving an expenditure of $25,000,000. I believe this a daring act of ignorance on their part, and a consulting board of wisdom and experience should be retained to supervise all features of the construction of this extraordinary large project."

Illustrative of the guessing as to future water requirements of Los Angeles and vicinity, I quote Franklin Thomas, vice-chairman of Metropolital Water District of Southern California. (Page 114 of the water supply papers above cited.) "The compilation just made, indicates that if the proposed diversion from the Colorado River were all used for sharply drawn domestic classifications it would all be needed within two decades from the present time, if local supplies were released to permit full development of adjacent agricultural lands." Just above this quotation Mr. Thomas says that 1,500 second-feet of water will be brought from Colorado River. This would supply 7,500,000 people with 130 gallons each per day. So Mr. Thomas' statement is equivalent to saying that he expects that 7,500,000 people will be residing in this district twenty years hence!

But why release any more water from the city water supply than is now being released for farm irrigation?

so simple a matter as the quantity of water needed per person, would it not be wise to submit the findings of all these engineers to a new board of engineers? Indeed it seems to me that before Los Angeles embarks upon a water project that may cost over a half billion dollars, every consulting hydraulic engineer should be consulted.

Failures of many of our big engineering projects and failure to complete many of them anywhere near the estimated cost, is usually not because of ignorance of engineers or estimators but primarily because of the penny-wise and pound-foolish practice of the political heads in charge of the

The Winston-Salem Sewage Treatment Plant with the Clarifiers in the Foreground

The Chemical and Mechanical Sewage Treatment Plant at Winston-Salem, N. C.

Biological Processes Discouraged in This Unusual Plant—Electrolytic Method Applied Successfully to a Strong Sewage—Satisfactory Effluent and Sludge Secured at Reasonable Cost

By CHARLES M. NELSON
Associate Editor, Water Works and Sewerage

THE sewage treatment plant at Winston-Salem, N. C., is remarkable for its design and for the success with which it is solving the sewage problem of the city. It is a chemical and mechanical sewage works, the units of which were assembled to meet the peculiar needs of Winston-Salem. As far as known, it is unique in the combination of processes employed. Since the plant went into operation in December, 1926, it has given consistently a satisfactory effluent and an easily-disposed-of sludge at a cost considerably below the estimated cost of other types of treatment. The notes presented here are based upon an inspection of the plant made in September, 1929.

The Sewage Problem at Winston-Salem

Winston-Salem has a population of 85,000; the population connected to the sanitary sewer system is about 75,000. The sewer system is of the separate type. The present flow is about 5.5 m.g.d., or about 73 gal. per capita per day.

The sewage of the city is of a particularly strong and disagreeable nature. Total solids are in excess of 1,000 p.p.m. The grease content ranges from 65 to 70 p.p.m. The raw sewage occasionally has a trace, but usually there is an entire absence, of dissolved oxygen when it reaches the plant. The treatment problem is complicated by the presence of industrial wastes, resulting from the manufacture of cigarettes and tobacco, textiles, furniture and dyes.

The design of the present plant was undertaken when the nuisance caused by a septic tank which had served the city for some years, became too great to continue this mode of disposal. The present plant is situated at the site of the old septic tank on a small stream southwest of the city, a little more than two miles from the central section. The flow of the creek ultimately reaches the Yadkin River about 11 miles below the plant. In a dry season the flow is frequently less than the flow of effluent from the plant.

In contemplating methods of treatment, a plant employing biological processes was looked upon with disfavor, principally for the reason that such a strong, difficult sewage was being dealt with. A scheme was sought by means of which the raw sewage might be turned into stable products as quickly as possible; the answer was found in a chemical and mechanical plant, not dependent for its results upon any form of bacterial activity. Immediate removal of coarse, obnoxious

solids is practiced and conversion of the remaining materials into stable compounds is accomplished by electrolysis of the sewage, rendered caustic by the application of lime.

Units Comprising Plant.—The essential units comprising the plant are shown diagrammatically in Fig. 1. The raw sewage passes through a bar screen and Detritors, to revolving-drum fine screens. From the screens the sewage passes to a lime-dosage tank and thence to a battery of electrolyzers. Clarifiers, sludge pumps, a secondary thickener, sludge filters and an outfall pump complete the apparatus. The plant is operated electrically, power coming from the city. The plant is equipped with a gasoline-engine-driven generator for emergency use. These units are considered in detail in the following sections.

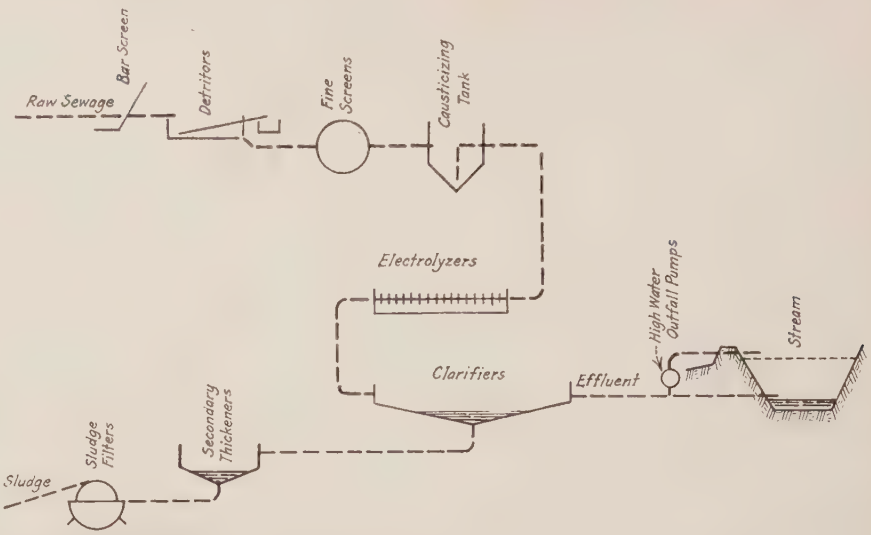


Fig. 1—Diagram Showing the Flow of Sewage Through the Winston-Salem Treatment Plant

Coarse and Fine Screening

The sewage of Winston-Salem is collected in several long gravity trunk sewers which converge above the plant. Screening is accomplished by a bar rack, grit chambers or Detritors and revolving fine screens.

Coarse Screening.—The bar screen is of the Dorr mechanically-cleaned type. For a period of time when the plant was first put into operation, the screen was cleaned by hand raking; this, however, was found undesirable as the loss of head caused by the accumulation of coarse material on the rack resulted in a variable flow—a disadvantage from the standpoint of subsequent processes. A further advantage is the elimination of the part-time services of one employee. The screenings are disposed of in the municipal incinerator plant.

Grit Chambers.—Dorr Detritors (see "Municipal News and Water Works," Feb., 1929, p. 81) in duplicate provide for the removal of grit. A high percentage of grit recovery is desirable in a mechanical plant, as the presence of grit might be expected to have some harmful effect upon the plant mechanism. The collecting tanks are 18 ft. square and the collecting mechanism of each unit is driven by a 1-hp. electric motor. Cleaning channels are 1¼ ft. wide and 28 ft. long. The cleaning rakes are driven by 2-hp. motors. The maximum capacity of the Detritors is 9 m.g.d. each.

The average total organic content of the grit recovered is less than 5 per cent. The grit is used for building roads about the plant. Figure 2 is a picture of the bar screen and the Detritors. Since the time this photograph was taken, a housing has been erected over the bar screen and the connecting walkway.

Fine Screens.—Fine screening is accomplished by two Dorrco revolving screens of the self-cleaning type. Screenings are disposed of at the municipal refuse plant, along with the screenings from the bar rack. The fine screens are cleaned of grease about once a month.

Electrolytic Treatment

The electrolytic treatment as yet is not completely defined as many reactions taking place are unknown, but research work is disclosing daily hitherto unknown interesting and instructive characteristics regarding the variety of reactions taking place in the electrolyzers. It is established definitely that nascent or atomic oxygen is developed, as well as hydrogen through the electrolysis of lime water. The reaction here is swift and selective, since in the atomic state the oxygen is avid for reaction, as are likewise the most putrescible or unstable matters in the sewage. This results in immediate stabilization of the most highly putrescible matters. This is indicated by the complete and immediate removal of odors, which does not take place when the electrolyzers are by-passed. It is also definitely established that there is a distinct aid given to subsequent sedimentation through a change in the charges on the ionized materials as explained by the colloid theories. Probably the most important reactions and yet the least definitely known are the electrolytic actions in forming completely different compounds as a result of energy supplied by the electric current passing through the sewage. Certain it is that obnoxious odors and gases are gone as soon as the electrolytic action has taken place and that all processes following electrolytic action deal with practically stable materials.

During the electrolytic action there is deposited on the electrode plates a film of calcium carbonate, rendering the electrodes passive and preventing

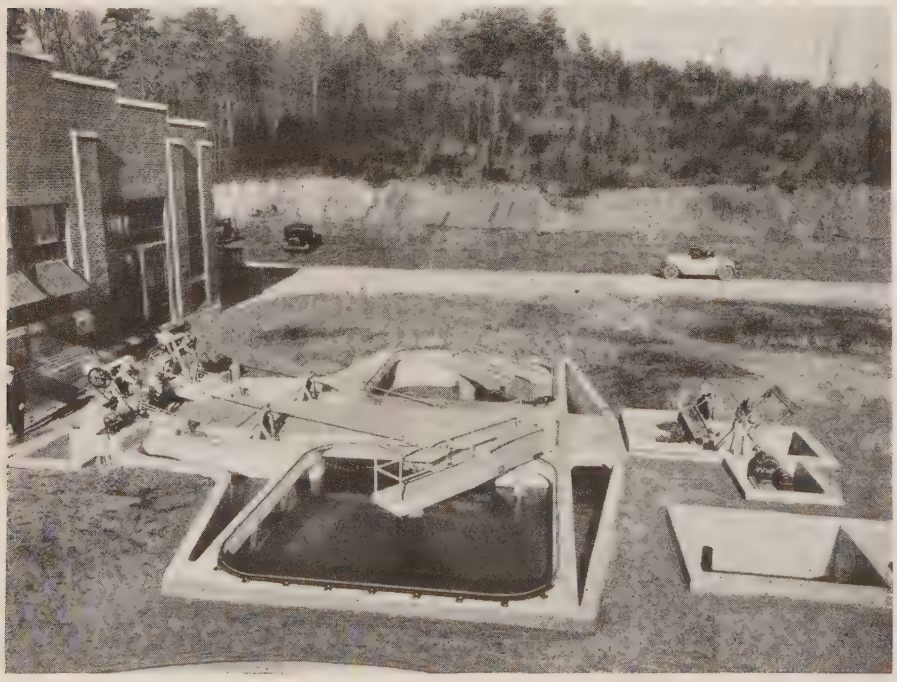


Fig. 2—Bar Screen and Detritors. A Housing Over the Bar Screen and Connecting Walkway Has Been Built Since This Picture Was Taken

the loss of the material constituting the plates which would take place if the sewage were not first rendered caustic. Mechanical agitators or scrapers are provided for the purposes of removing grit and film from the electrodes, preventing polarization and insuring intimate contact of the sewage with the electrodes. The equipment used for the alkalinization of the sewage and the electrolysis of the lime-sewage mixture consists of tanks for the preparation of the lime solution, apparatus for controlling the lime dosage, a mixing tank and the electrolyzers.

Solution Tanks.—Tennessee quicklime is stored in bulk and slaked at the plant. A 3 per cent milk of lime is made up, effluent from the outfall being used in place of fresh water. The solution is piped to the dosage-control apparatus at scouring velocity in order to prevent encrustation of the pipes. The flow required to prevent loss of diameter is in excess of the amount required for admixture with the sewage.

Control of Dosage.—The sewage is metered by a General Electric flow meter as it passes from the fine screens. Milk of lime is now admitted to the sewage through the dosage apparatus to give a causticity of 50 p.p.m. This apparatus, which is illustrated in Fig. 3, consists of a Leeds & Northrup controller and a motor-operated tilting weir box.

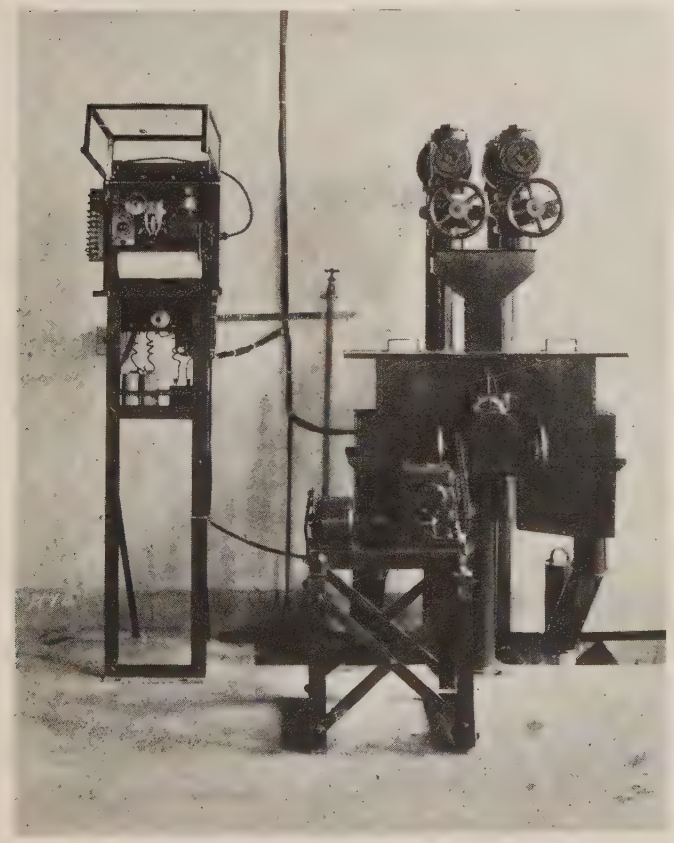
Milk of lime in excess of the maximum sewage demand is admitted uniformly to the central compartment of the weir box, which contains overflow weirs at each end. The flow over one weir is returned by gravity to the lime solution tank, and that from the other weir is applied to the sewage prior to its entrance to the reaction or causticizing tank. When the box is horizontal the flow of lime solution is evenly divided; any change from the horizontal position alters the elevations of the two weir crests and thus regulates the lime dosage. The position of the box is governed by the controller, which is actuated by the potential created between a tungsten electrode and a calomel half-cell immersed in the sewage at a point downstream from the lime application. This potential is a function of the hydroxyl-ion concentration of the limed sewage and its variation indicates a change in the lime demand of the sewage. Thus, by converting the variations in potential into corresponding movements, as regards both degree and direction, of a contact cam in the weir-box motor circuit whereby the position of the box is regulated, lime is applied to the sewage in accordance with the demand.

Causticizing Tank.—Thorough mixture of the lime solution and the sewage is secured in the causticizing tank, which is a circular concrete tank with a conical bottom. The sewage enters tangentially and is siphoned off from the bottom of the tank. From the tank it flows to the electrolyzers.

Electrolyzers.—The lime-sewage mixture passes over equalizing weirs to four electrolyzers. Space remains for a fifth unit, in which an experimental cell of 1-m.g.d. capacity is now installed. Figure 4 shows one of the four units with the covers removed, and Fig. 5 is an early view of the plant with only two units in place. Each electrolyzer has a normal capacity of 3 m.g.d., giving the present equipment a total capacity of 13 m.g.d.

Each of the four concrete tanks contains 18 rows of 90 vertical iron plates. The plates are 25x16 in. in size and are spaced ⅜ in. apart. Direct current is supplied from motor-generator sets at approximately 35 volts and from 125 to 150 amp. The 18 tanks are connected in series and the 90 plates in each row are placed in parallel, the plates being alternately positive and negative; thus the drop between plates is about 2.0 volts. Pyralin scrapers, in contact with the surfaces of the plates, are driven from below by a crank-and-connecting-rod gear. The tanks are covered with removable covers, which allows cleaning of the plates by hand when necessary. This is done once a month. The plates have an estimated life of three years. The lime and electrolytic equipment was installed by the Direct Oxidation Process Corp., of Philadelphia, Pa.

Experimental Electrolyzer.—A new type of electrolytic cell is now being demonstrated at the Winston-Salem plant, utilizing hydraulic cylinders in place of the crank-and-connecting-rod gear for the operation of the scrapers or depolarizers. The dimensions of the electrodes and the length of the scraper travel have been so increased that one



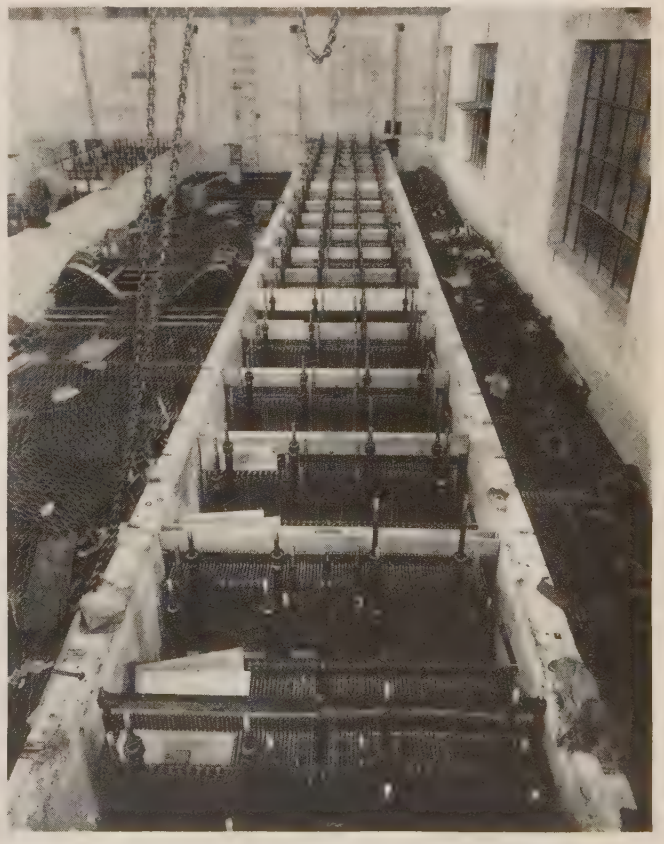


Fig. 3 (Left)—Lime-Dosage Control, Showing Tilting Weir Box at Right; Fig. 4 (Right)—One of the Electrolyzer Units with Cover Removed

Fig. 5—The Electrolyzer Room at Winston-Salem. Two Additional Batteries and an Experimental Cell Have Been Since Installed

bank of electrodes is equivalent to six banks of the former design, resulting in a net decrease of about 80 per cent in the number of moving parts required for the actuation of the scrapers for a given treatment capacity. As a result of the increased plate dimensions and the consequent reduction in the number of plates, the hydraulic operating head has been reduced to but a fraction of that required for the under-driven cell, and the overall length of a unit of given capacity has been reduced some 30 per cent. In spite of this reduction, the new cell has larger clear spaces between consecutive banks of electrodes. This facilitates internal examination and maintenance. The electrical energy is supplied by low-voltage generators. This eliminates the stray currents experienced with older designs in which a large number of relatively small banks of electrodes were connected in series across the terminals of a high-voltage generator, and reduces the corrosive effect on the internal parts of the equipment with consequent savings in maintenance and repair. The entire actuating mechanism is placed above the cell, making it more accessible and reducing the cost of installation of this type of electrolyzer. It is anticipated that the new type of cell will be substituted for the units first installed as soon as replacement becomes necessary.

Sedimentation and Filtration

From the electrolyzers, the sewage flows to two clarifiers, from which the effluent passes to the stream and the slurry to a secondary thickener and, finally, sludge filters.

Clarifiers.—Sedimentation equipment comprises two rectangular Dorr clarifiers. The theoretical detention period for a 9-m.g.d. flow is one hour. At the present rate of 5.5 m.g.d. the detention period averages three hours. American Well Works pumps are provided for raising the level of the outfall at times of high water. Some of the effluent is used at the plant for making up the lime solution and, raised to a high pressure, for cleaning out the clarifiers. The slurry, which has a moisture content of about 95 per cent, is pumped by Dorr sludge pumps to a secondary thickener.

Thickener.—The moisture content of the sludge is reduced to about 88 per cent in a circular Dorr thickener, 50 ft. in diameter. Lime is added to the sludge after thickening, just before filtration. When operation was first begun, the sludge was not conditioned with lime and it was found that the considerable grease content of the sludge interfered with subsequent filtration; with the addition of lime, however, this fault was done away with.

Sludge Filters.—Sludge is filtered in two vacuum-drum filters, manufactured by the Filtration Engineers, Inc. The filters are fed from the thickeners by a pump, the overflow from the filters draining back to the thickeners by gravity. The capacity of the pump is slightly in excess of the capacity of the filters, so that there is always a rising current in the sludge reservoir beneath the filters.

Each filter consists of a drum 8 ft. 6 in. in diameter and 8 ft. long, rotating on a horizontal axis. The lower part of the drum dips into a tank containing the sludge. The drum is made of heavy sheet steel, divided by longitudinal members spaced approximately 1 ft. apart; thus each 1-ft. strip around the circumference forms a separate filter. The steel drum between the division members forms a drainage compartment. Openwork hose duck is stretched around the entire drum to protect the filter cloth from mechanical wear against the drainage members. The filter cloth is sealed in the division members and around the edges of the drum so that each compartment is a separate filter unit.

A pipe leads from each compartment to a control valve, which consists of a rotating hub into which all the pipes are assembled. As the hub rotates, each pipe coincides momentarily with ports in a stationary collecting ring surrounding the hub. As a compartment dips into the sludge reservoir, a vacuum is created within the compartment, with the result that the liquor is pulled through the filter cloth, leaving the solids on the outside. As the compartment leaves the reservoir, the suction within is increased and the moisture content of the solids deposited on the filter cloth is reduced appreciably. The sludge cake is released by admitting air under atmospheric pressure to the compartment when the point of discharge has been reached.

The sludge cake, which varies from ¼ to ½ in. in thickness, is peeled from the drum by cords. The moisture content of the sludge averages from 60 to 66 per cent. Sludge is produced at the rate of about 30 tons a day. As the sludge comes from the drums it is elevated to a hopper by belt conveyors.

Final disposal of the sludge is made in a near-by field having an area of approximately 20 acres. The sludge is drawn out by a mule team and dump wagon. The sludge is allowed to dry on the ground for a period of from 2 to 4 weeks and is then disked over with a harrow to open it up and further the drying process. Up to the present time three or more layers of sludge have been deposited over the area of the field.

Adaptability to the mechanical system of sewage treatment and to variable conditions met from day to day are features of this sludge-filtering installation. The solids are separated out readily, and the moisture content of the sludge cake is exceedingly low. The string discharge method eliminates any reversal of current to lift the cake from the filter cloth, with the result that no portion of the filtrate lying in the drainage system is blown back into the discharged cake. This assures the maximum moisture reduction. Another important element is the use of a very cheap grade of filter cloth which will not plug up, but will wear out in about three weeks' operation; thus a prime filtering condition is maintained at all times.

Results of Treatment

Aside from considerations of cost, the success with which the plant is performing its work may be judged by the ability to dispose of its products without nuisance and the degree to which the plant itself is offensive to surrounding inhabitants. One of the things that impresses a visitor to the Winston-Salem plant most is the freedom from

disagreeable odors all through and about the works, the only exception being a small area about the bar screen and Detritors, where the raw sewage is received. A strong and not unpleasant odor of lime pervades the slaking and sludge-filter rooms and, to a lesser extent, the electrolyzer room. Offensive odors are apparently killed as soon as the electrolysis is begun. The absence of hydrogen sulphide is attested by the freedom of the copper bus-bars and knife switches on the panels controlling the motor-generator sets from any deposit of sulphide.

Effluent. — Characteristics of the treatment are a high removal of dissolved and suspended organic matter and an increase in dissolved-oxygen content from nearly nothing to a figure approaching that of the stream in which final disposal is made. The organic compounds in the effluent are largely stable. In appearance, the effluent is not especially clear, being in this respect probably not as good as activated-sludge effluent. Discoloration is caused by dye wastes, and the cloudiness of the effluent results from the presence of calcium carbonate, which probably accounts for about 50 per cent of the suspended solids. Further clarification could be accomplished by additional processes if there were any need for this.

The plant is provided with a chemical laboratory and is under chemical control. While the regular routine analyses are made, presumptive tests are not relied upon to furnish indices of the quality of effluent secured. In place of such tests, a thorough sanitary survey of the stream carrying the effluent is made once a month, about and for a considerable distance below the outfall. The survey includes physical, chemical, biological and bacteriological tests of the stream. The examination of the creek is conducted by the plant chemist and the engineer in charge, in a canoe.

As a result of these periodic analyses it has been established that there are no desposits of sludge in the bed of the stream and that there is no evidence of gassing or anaerobic decomposition. There are no offensive odors; indeed, the only odor given off by the effluent is the characteristic lime odor found at the clarifiers and outfall. Organisms which might indicate pollution are absent. The dissolved-oxygen content of the stream is restored to normal within a few miles below the outfall. These results are not confined to any particular season, but are secured throughout the year—even during the extreme summer heat and in the dry month of September, when the flow of the creek is at times less than the quantity of effluent discharged. From the examination of the stream it may be stated definitely that a thoroughly satisfactory, non-septic effluent is being secured.

Sludge.—Equally satisfactory is the quality of sludge resulting from the treatment. The cake has the odor of lime as it comes from the filter drums. It contains about 50 per cent calcium carbonate and for this reason is more bulky than the sludge ordinarily obtained from biological treatment processes. The sludge dries easily. It is a stable product and it remains stable under all conditions. The area on which it is deposited is low, marshy ground, frequently inundated by overflow of the stream into which the effluent flows. In spite of this, there is no period of the year when offensive odors or nuisance of any sort can be detected.

While no attempts to market the sludge have been made, it obviously possesses value as a fertilizer. Corn from 12 to 14 ft. in height was observed growing on the disposal tract late in September. Experiments are under way, however, to determine if it is economically feasible to recover the lime by burning the oxidizable content of the sludge. If it is found cheaper to recover the lime in this fashion than to buy lime, this step will be taken and sludge will no longer be wasted.

Cost of Treatment

The present plant, which is capable of treating a flow of 13 m.g.d., was built at a cost of $650,000. It is estimated that the capacity can be increased to 15 m.g.d. by the expenditure of an additional $75,000. The cost of the plant is considerably below the estimated cost of any of several types of biological plant considered.

Operating Cost.—The cost of treatment is at present $25.88 per million gallons, based on the present actual flow of 5.5 m.g.d. The cost of operation may be itemized as follows:

Salaries and labor	$ 9.04
Lime	6.79
Power	2.64
Current for electrolysis	0.80
Repairs and replacements	3.56
Supplies	1.64
Miscellaneous	1.41
Total	$25.88

This is equivalent to about 69 ct. per capita of connected population per annum.

The operating cost given does not include cost of capitalization. Based on a charge of 7 per cent, this reduces to $9.59 per million gallons. Since certain items of operating cost will not increase with an increase in flow, the unit operating cost may be expected to decrease as the population of the city increases. It may be noted that the cost of treatment at Winston-Salem does not suffer by comparison with operating costs where other processes are employed under similar conditions.

The Winston-Salem treatment plant was designed by Harry L. Shaner, commissioner of public works. W. E. Thrasher, engineer of operations and maintenance, is in charge of the plant. R. M. Rodgers is plant chemist and M. O'Shea is plant superintendent.

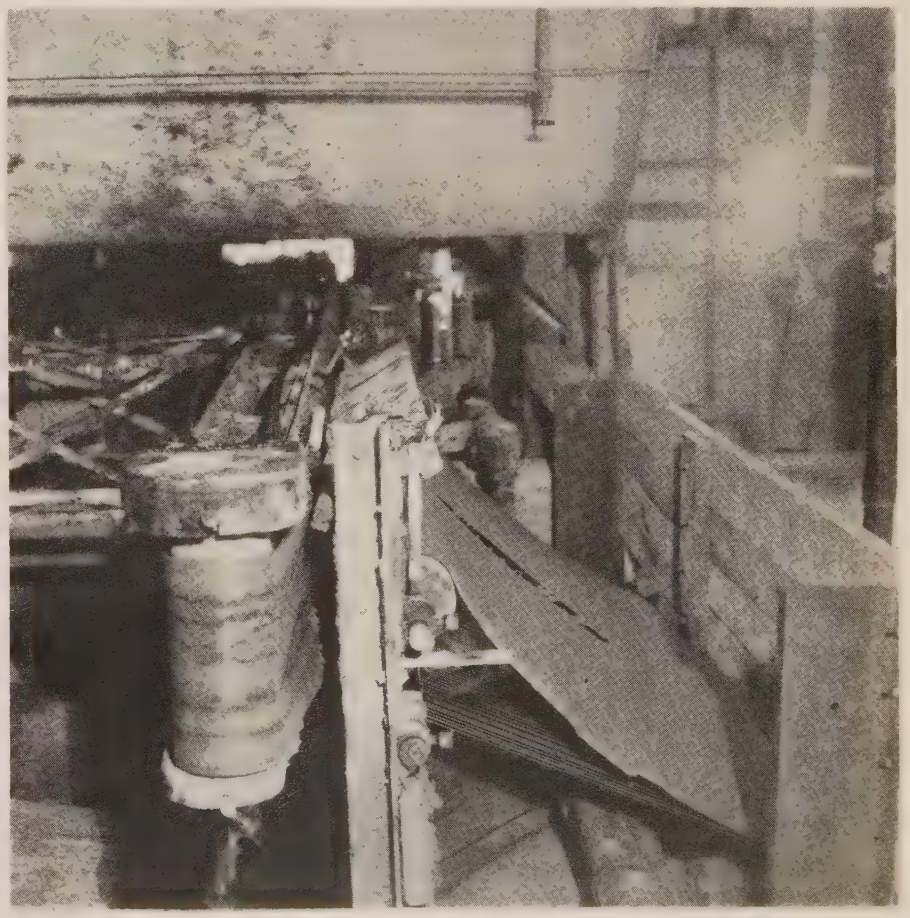


Fig. 6—Discharge of Sludge Cake from Filter

New Municipal Construction in 1930

Probable Construction Expenditures of Some of the Larger Cities for Municipal Improvements; Figures from Questionnaire Sent to City Engineers of 100 Cities of Over 30,000 Population

City and State	Probable Total Expenditures for Municipal Improvements	Water Works	Sewers	Paving	Bridges	Airports	Miscellaneous
ALABAMA							
Birmingham	.....	.....	$ 50,000	$1,000,000	.....	$1,000,000	$4,500,000[1]
Montgomery	$ 750,000	$ 50,000	100,000	.....	.....	.....	200,000
CALIFORNIA							
Berkeley	.....	.....	240,500	442,000	.....	.....	.....
Long Beach	.....	.....	450,000	2,106,255	$ 250,000	.....	.....
Los Angeles	.....	.....	4,079,000	9,328,000	2,593,000	.....	.....
Oakland	8,000,000	*	*	*	*	*	*
Pasadena	1,558,000	*	*	*	*	*	*
San Diego	4,963,000	.....	645,000	4,203,000	115,000	.....	.....
San Francisco	.....	4,800,000	925,000	7,500,000	500,000	200,000	9,100,000[2]
Stockton	.....	.....	.....	.....	.....	.....	4,043,000
COLORADO							
Colorado Springs	.....	70,000	60,000	134,000	10,000	.....	.....
Pueblo	30,000	*	*	*	*	*	*
Denver	3,520,800	*	*	*	*	*	*
CONNECTICUT							
Hartford	.....	.....	50,000	761,675	1,900,000	.....	.....
New Haven	.....	500,000	75,000	100,000	.....	235,000	.....
Stamford	500,000	*	*	*	*	*	*
DELAWARE							
Wilmington	.....	1,500,000	180,000	250,000	.....	.....	.....
FLORIDA							
Jacksonville	.....	.....	.....	300,000	12,000	.....	40,000
Tampa	.....	20,000	165,000	285,000	.....	750,000	.....
ILLINOIS							
Danville	250,000	*	*	*	*	*	*
Elgin	.....	.....	15,000	280,000	.....	.....	.....
Oak Park	.....	25,000	5,200	483,800	.....	.....	.....
Peoria	.....	400,000	650,000	.....	500,000	.....	.....
Rockford	800,000	*	*	*	*	*	*
Springfield	.....	6,000	4,800	482,600	10,000	.....	200,000
IOWA							
Cedar Rapids	.....	50,000	300,000	100,000	.....	.....	.....
Sioux City	.....	.....	145,000	256,000	60,000	.....	.....
KANSAS							
Kansas City	$ 400,000	*	*	*	*	*	*
Wichita	.....	.....	$ 100,000	500,000	335,000	200,000	250,000
KENTUCKY							
Lexington	.....	.....	12,500	220,000	190,000	.....	.....
Louisville	.....	$ 250,000†	2,000,000	1,600,000	.....	.....	2,900,000[3]
LOUISIANA							
New Orleans	.....	.....	6,000,000[4]	4,000,000	.....	.....	10,250,000[5]
MARYLAND							
Baltimore	.....	3,195,000	2,600,000	1,600,000	4,000,000	1,120,000	8,238,000[6]
MASSACHUSETTS							
Boston	.....	.....	1,500,000	2,000,000	.....	.....	.....
MICHIGAN							
Battle Creek	.....	125,000	150,000	125,000	.....	.....	.....
Detroit	.....	.....	12,000,000	6,900,000	1,400,000	.....	.....
Flint	.....	1,000,000	800,000	.....	.....	.....	350,000
Grand Rapids	.....	200,000	150,000	800,000	.....	.....	850,000
Lansing	.....	.....	400,000	.....	125,000	.....	.....
Pontiac	.....	.....	500,000	.....	.....	.....	.....
MINNESOTA							
Duluth	400,000	*	*	*	*	*	*
St. Paul	.....	100,000	500,000	1,000,000	976,000	295,000	.....
MISSOURI							
St. Louis	.....	.....	4,050,000	5,650,000	500,000	300,000	1,500,000[8]
NEBRASKA							
Lincoln	.....	250,000	25,000	340,000	.....	.....	50,000
Omaha	.....	.....	500,000	400,000	.....	.....	.....
NEW JERSEY							
East Orange	250,000	*	*	*	*	*	*
Newark	.....	1,000,000	.....	3,000,000[9]	.....	.....	4,000,000[10]
Trenton	.....	.....	.....	500,000	.....	.....	.....
NEW YORK							
Buffalo	.....	.....	2,000,000	2,000,000	1,000,000	.....	.....
Niagara Falls	.....	50,000	250,000	200,000	.....	.....	.....
Rochester	2,000,000[11]	*	*	*	3,000,000	*	*
Yonkers	4,500,000[12]	*	*	*	*	*	*
NORTH CAROLINA							
Winston-Salem	1,500,000	*	*	*	*	*	*

*Expenditures not itemized. †By water company.

[1] Includes $3,000,000 for widening and deepening creeks and $1,500,000 for track elevation work (under construction). [2] $1,000,000 for incinerator $8,000,000 for public buildings, $100,000 for playgrounds. [3] $2,000,000 for grade elimination, $900,000 for school buildings. [4] For sewerage, water and drainage extensions. [5] $8,000,000 for lake front development and other levee work, $2,000,000 for public schools, $250,000 for docks. [6] Parks $178,000, conduits $300,000, schools $2,700,000, library $2,000,000, city hospitals $2,500,000. [7] Five miles of pavement. [8] For buildings. [9] Street paving, bridges and other related municipal work. [10] Subway work $1,000,000, Port Newark development and airport $3,000,000. [11] For sewers, paving, sidewalks, etc. [12] New building for health shelter, new school buildings, two combination fire and police stations and extensive paving and sewer construction. [13] Probable construction work $3,000,000; in addition $1,000,000 for street maintenance and minor reconstruction; bond issues as follows contemplated: For Municipal University, $427,000; park department, $145,000; playgrounds, $350,000; traffic lights, $200,000; hospital, $290,000; airport, $500,000. [14] Grade crossing elimination under direction of Dayton Union R. R. [15] Includes $1,000,000 city hospital. [16] Paving and sewering. [17] Union station, grade separations and track revisions. [18] Street and sewer construction. [19] Includes $150,000 garbage disposal plant, $750,000 grade crossing elimination and $300,000 park development. [20] Includes $2,250,000 for wharf construction. [21] Grade separation. [22] Gas and water. [23] Two miles of sewer, 3 miles of sidewalks, 2 miles of water mains. [24] Proposed 2.5 miles paving, 8 miles sidewalks, 5 miles of water mains, 5 miles of sewers.

City and State	Probable Total Expenditures for Municipal Improvements	Water Works	Sewers	Paving	Bridges	Airports	Miscellaneous
OHIO							
Akron	.....	400,000	900,000	4,300,000	750,000	300,000	.....
Cincinnati	3,000,000[13]	.....	500,000	*	.....	*	*
Cleveland	8,000,000	*	*	*	*	*	*
Columbus	.....	300,000	2,000,000	1,000,000	.....	.....	.....
Dayton	.....	.....	250,000	300,000	.....	.....	25,000,000[14]
Lakewood	.....	29,500	40,850	157,000	.....	.....	1,147,000[15]
Lima	.....	.....	1,170,000	70,000	.....	.....	.....
Youngstown	.....	225,000	630,000[16]	500,000	500,000	.....	.....
OKLAHOMA							
Tulsa	.....	400,000	1,000,000	1,450,000	.....	.....	1,500,000[17]
OREGON							
Portland	.....	1,079,000	2,000,000[18]	190,000	255,000	.....	.....
PENNSYLVANIA							
Erie	.....	1,700,000	1,500,000	500,000	.....	.....	1,350,000[19]
Scranton	500,000	*	*	*	*	*	*
Wilkes-Barre	250,000	*	*	*	*	*	*
RHODE ISLAND							
Providence	.....	800,000	1,842,000	1,750,000	648,000	.....	250,000
SOUTH CAROLINA							
Columbia	100,000	*	*	*	*	*	*
TEXAS							
Beaumont	.....	125,000	2,600,000	1,350,000	.....	100,000	2,325,000[20]
El Paso	.....	.....	167,000	85,000	.....	15,000	215,000
Ft. Worth	.....	.....	400,000	1,000,000	250,000	.....	8,000,000[21]
VIRGINIA							
Lynchburg	.....	30,750	43,800	75,600	5,000	.....	.....
Norfolk	.....	.....	.....	450,000	650,000	.....	.....
Richmond	.....	300,000[22]	500,000	700,000	1,500,000	.....	700,000
WASHINGTON							
Spokane	450,000	*	*	*	*	50,000	*
WISCONSIN							
Green Bay[23]	.....	.....	.....	.....	.....	.....	.....
Kenosha[24]	.....	.....	.....	.....	.....	.....	.....
Madison	.....	75,000	60,000	400,000	.....	.....	660,000

Effects of Cold Weather and Drought on British Water Supplies

Heavy frosts and a long extended drought caused much trouble for water works operators of Great Britain in 1929. In its annual review The Engineer summarizes these happenings as follows:

The year 1929 will long be remembered by many water works engineers as one of grave anxiety. There were, first of all, the severe frosts of the early months, which took their toll of burst water mains and pipes, besides introducing difficulties at filtration works. Then there was a drought which persisted, in some places, practically without break from early in the spring until the end of September, and finally, there were the excessive rains and floods of November and December. The number of burst water mains in the metropolitan area were, to all seeming, more frequent and serious than usual, through it was officially stated that the occurrences were neither extraordinarily numerous nor extraordinarily severe. Moreover, it was announced by the Works and Stores Committee of the Metropolitan Water Board, on which falls the duty of maintaining supplies in the London area, that though, undoubtedly, severe cold might and did occasion fractures of mains, it was not the only cause of such failures, and the committee pointed to the injuries brought about by the increased speed and weight of modern traffic as contributory factors. However, the committee decided to appoint a sub-committee specially to consider and report on the subject. The Council of the Institution of Water Engineers also appointed a strong committee of water works engineers to investigate the matter. This committee has not yet completed its inquiries.

Throughout the country the total number of burst service and other pipes must have been enormous. Approximate figures for two places, at any rate, are available. In Liverpool, it is said, there were some 29,000 burst pipes, and, as a consequence, nearly 130,000,000 gal. of water were lost. It is estimated that the total number of burst pipes in Burnley was 19,500 and that the loss occasioned by damage to meters, lavatory fittings, cylinders, etc., was some $200,000.

In some parts of the country the drought in the early part of the year was more pronounced than in others. Yorkshire began to suffer early. For the five months from February to June inclusive the precipitation was only just over 3.0 in., which is, of course, far below the average. Before the end of June, Barnsley, Batley, Bradford, Dewsbury, Doncaster, Halifax, Huddersfield, Leeds—to name just a few—had began to feel the effects, some of them severely. Bradford's supplies, it was reported, had not been so low since the early 'eighties. Halifax had more than 425,000,000 gal. less in its reservoirs than at the same time the year before. At Hull the water level in the wells from which its supplies are drawn was some 20 ft. below normal. Leeds had only 106 days' supply in store, as compared with 150 days in 1928 and 165 in 1927. Reports for other parts of the country showed the position to be quite as bad, if not worse. The East Cheshire authorities, for example, gave notice that if the drought did not break they would have to shut off supplies. In Edinburgh in the beginning of July the position was described as being "very serious." In many villages in Essex water had to be carted some distance and was sold at so much a bucket. At a village in Buckinghamshire as much as 4 ct. a gallon was being given a little later in the year. Similar instances might be adduced almost indefinitely. There is no doubt that much inconvenience was experienced throughout the land, and that over a wide area a great deal of hardship had to be undergone.

In the metropolitan area, though there was never any real shortage—thanks to the large volumes in the reservoirs, which were heavily drawn upon—restrictions prohibiting the use of water for garden watering through hoses and the cleaning of motor cars had to be imposed. It is probable, however, that that measure would not have been resorted to had consumers as a whole "played the game"—if we may be permitted to use such a colloquialism—when asked to be careful of the water, instead of—as they did—using an average of 30,000,000 gal.—or approximately 4 gal. a head—more per day than before the request was promulgated.

Another trouble, attributable to hot weather, was the excessive algal growths in reservoirs which was experienced in many places.

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How Silting Shortens the Lives of Some Reservoirs

That a certain reservoir would lose 95 per cent of its original capacity in 13 years, as a result of silting, would have seemed improbable 35 years ago, yet such is the fact. We refer to the 32,000 acre-foot reservoir at Austin, Texas, which was put into service in 1913 and was almost full of mud from the Colorado in 1926. A 49,300 acre-foot reservoir built at Austin in 1893 lost 48 per cent of its capacity in eight years, or at the rate of 6 per cent per annum; and the one built 20 years later lost capacity at the rate of 7.3 per cent per annum.

The Roosevelt reservoir on Salt River, in Arizona, lost 7 per cent of its capacity in the first 20 years (1906-1925), or only 0.35 per cent per annum. The Elephant Butte reservoir on the Rio Grande in New Mexico, lost 9 per cent of its capacity in 11 years (1915-1925), or at the rate of 0.8 per cent per annum. On the other hand, the McMillan reservoir on the Pecos River in New Mexico lost 42 per cent of its capacity in 10 years (1895-1904), or at the rate of 4.2 per cent per annum; and the Zuni reservoir on the Zuni River in New Mexico lost 95 per cent of its capacity in 22 years (1905-1927), or at the rate of 4.3 per cent per annum. The Buckhorn reservoir on Buckhorn Creek, Colorado, lost 47 per cent of its capacity in 18 years (1907-1925), or at the rate of 2.5 per cent per annum. These data on silting of reservoirs appeared in the November issue of *Water Works and Sewerage,* being abstracts of a discussion by R. L. Meeker.

If the life of these reservoirs is determined by the rate of silting, we have:

Reservoir	Life, years
Austin (Tex.)	14 to 17
Roosevelt (Ariz.)	286
Elephant Butte (N. M.)	125
McMillan (N. M.)	24
Zuni (N. M.)	23
Buckhorn (Colo.)	40

As we recall it, engineers have estimated that the proposed Boulder Dam reservoir on the Colorado River will silt up at the rate of only 1 per cent per annum. If so, its life will be 100 years, provided that it can not be economically de-silted. Suggestion has been made that silt can be sluiced out of such reservoirs, but how and at what cost? And during the sluicing process, what will become of the community that depends on the reservoir for its water supply? What will be the damage to lands in the lower reaches of a river, if great masses of silt are sluiced out?

In making estimates of the rate of silting up of reservoirs, bad errors are apt to occur, both because of great fluctuations in the percentages of silt carried in suspension and because of incorrect estimates of the material pushed along the bed of the stream. The eroding power of a stream increases much faster than does the volume of water that it delivers. Hence estimates of silt percentages based on subnormal flows may be very misleading. There enters also the problem of erosion and silt conveyance during very short periods of exceptionally heavy floods. There is almost nothing in print on this phase of the problem, and the meagreness of the published data doubtless reflects the ignorance that prevails on this subject even among well informed hydraulic engineers.

During more than a decade, rainfall has been subnormal in most of the drainage basins of our western streams, hence percentages of silt carried by most of those streams have been even more below normal than the runoff.

Many of the flood prevention dams that have been recently built and are under construction seem destined to have lives so short that the taxpayers will be badly "jarred" a few years hence unless engineers learn more about rates of silting than is now known and make clear to the taxpayers what life is to be expected for such dams.

Should Los Angeles Go to the Colorado River?

Should the Los Angeles district go to the Colorado River for water? Judging by the silence as to other sources of water supply, it might be inferred that there is none worthy of mention. The article by W. A. Gillette in this issue of *Water Works and Sewerage* makes it evident that the Mono Lake and Walker River basins on the east slope of the Sierra Nevadas have runoffs and reservoir sites adequate to take care of the probable increase of Los Angeles county population for the next 20 years. Los Angeles is now securing a large part of its water from the Owens River drainage basin just south of Mono Lake and is preparing to secure a small additional supply from the Mono Lake basin. Mr. Gillette quotes runoff statistics compiled by the State Engineer of California showing that the Owens River, Mono Lake and Walker River basins have a mean annual runoff of almost 1,500,000 acre-feet.

The city of Los Angeles at present consumes 120 gal. of water daily per person, and at that rate one annual acre-foot would supply 7.3 persons. Hence the 1,500,000 annual acre-feet would supply a city of about 11,000,000 people, if all of the water could be col-

lected and delivered. It is safe to estimate that 50 per cent can be delivered, which means that 5,500,000 people can be supplied from that source. Close to Los Angeles there are four river basins whose mean annual runoff is nearly 700,000 acre-feet, according to the State Engineer's estimates, namely, the basins of the Santa Ana, San Gabriel, Santa Clara and Los Angeles rivers. Adding their runoffs to that above given and assuming only 50 per cent delivered to consumers, there would be enough to supply an urban community of 8,000,000 people, which is a population more than threefold the present population of that district.

This being the case, why have the residents of that district been led to believe that it is imperative to go to the Colorado River, and to start going at once? Are the runoff data published by the State Engineer erroneous? If so, no public statement has been made to that effect. Will it cost more to conserve and use this California supply of water than to go to the Colorado River? If so, where are the published comparative estimates of cost that prove such a contention? Is Los Angeles growing so rapidly that it will be bigger than New York City and Philadelphia combined in ten years? One might think so, to read about the imperative need of water from the Colorado River.

It is not easy to put a finger upon the causes of so much silence as to California sources of water and so much talk about the Colorado River. We suggest the following as among the reasons.

Los Angeles has a municipally owned power and light plant in which $75,000,000 is invested. It has condemned and bought the electric distribution system of one power company and has just announced its desire to secure that of the other company. The heads of this power department see a big block of hydroelectric power available from the Colorado River project, and one securable at by-product prices if Los Angeles goes to the Colorado for water. They see the financing of this development by the U. S. Government, and they fear that the local voters will refuse to finance any further great expansion of the power department. Indeed, they are struggling right now to persuade the government not only to build the dam but to build the power plant at the dam, thus leaving only the transmission lines to be financed by the city of Los Angeles. This is, we believe, one reason why the citizens of Los Angeles have been told so little about California sources of water supply. And in this connection it should be noted that the water department is affiliated with the power department and that the power end wields the greater political power, or at least has the most active politicians on its salary list.

Two of the large dailies in Los Angeles are strong advocates of municipal power, and the owner of a third daily is said to be interested in arid lands that will be irrigable if the Colorado River project is put through. Hence their readers are not apt to be presented even with such information as we are giving in these columns.

In a previous editorial article we showed that about half the water that is to be brought from the Colorado to the Los Angeles district is to be used for irrigation, but that that fact is not made clear in the reports, because the wording is "Domestic, irrigation and other uses on balance of area." The "domestic" part of that item is negligible, and the irrigation item is almost the whole thing, but none but an engineer would be apt to know it. If the citizens of Los Angeles want to finance farmers to at least half the cost of the Colorado River project, well and good. But at least those citizens should be told that they are about to do that very thing if they approve the bond issue that will soon be presented to them.

The third reason—and perhaps the most important one—why the Colorado River project has been kept in the limelight to the complete exclusion of any alternative is this: It was originally believed that the federal government could be induced to build the Colorado River dam, and not place any of the burden of its cost upon those who would benefit by it. But this plan could not be put through congress, so a compromise plan was evolved. The federal government is to furnish the capital for the dam, but power is to be sold wholesale at prices that will pay interest on that capital and amortize the investment in 50 years. This sounds very nice, and would be very nice for Los Angeles, were there no economic alternative to going to the Colorado River; for it relieves Los Angeles of financing about half the entire cost of the project inclusive of the aqueduct. Having started along the Colorado River path to get more water, Los Angeles politicians, newspapers and even engineers are reluctant to seek another path.

But what about the board of consulting engineers that is now working on its report? The trouble there is that only two major questions have been put to that board, namely, where the dam should be built on the Colorado and what route the aqueduct should take. A question of far greater importance has not been put to them, namely: Is there any other source of water supply for Los Angeles that will be cheaper than the Colorado River project, at least for the next decade or two?

That question should be put to several distinct boards of consulting engineers selected by different public officials.

We recall the different reports on the Isthmian canal problem about 30 years ago. There were radical differences of opinion as between the Nicaragua and Panama routes; and when the latter was selected, there were equally radical differences of opinion as to whether it should be a sea-level or a lock canal. It was indeed fortunate that more than one board investigated that problem. Our belief is that every large project calls for several entirely independent investigations by the most competent engineers available. In the present case, a board of experienced electrical engineers should be employed, in addition to several boards of hydraulic engineers. It is our impression that as a power project the Colorado River project is an economic blunder of the first order. As an irrigation project it seems equally doubtful. As a city water supply project, the evidence is strongly against it. As a combination of all three projects, it may be a wise one; but the taxpayers are surely entitled to know to what extent they are going to be asked to finance (1) power, (2) irrigation and (3) city water plants.

More than 12 years ago the editor was a consulting engineer for two power companies in California, and thus came to have a fairly broad knowledge of water supply conditions in that state. Since then he has had no connection with those companies or any other

utility companies in California, and holds a brief for no one. He believes that a great economic mistake is pending in the Los Angeles district. He is not sure that it is to be a mistake, but he is sure that the public is entitled to have, and should insist upon, a much broader engineering investigation of all the problems above indicated.

"We Can't Foretell Weather from What Has Gone Before"

Commenting upon the exceptionally dry autumn on the Pacific coast, one of the forecasters for the Weather Bureau said: "We can't foretell weather from what has gone before." This is undoubtedly true as to our Weather Bureau methods, and it is all the more discouraging when it is remembered that the Bureau has been in existence more than 60 years and has expended many millions of dollars in gathering and publishing weather statistics. Almost the only use of rainfall records is in forecasting the amount of water that will probably be available. But in many large sections of the country it is not unusual to have rainfall of one year amount to less than one-third the rainfall of the previous year. The runoff variations are of course much greater than that.

The runoff produced by the San Gabriel River, California, during the dry period of 1893-1904 was less than 24 per cent of that during the wet period of 1883-93, the rainfall during those two periods averaging 11.3 and 20.3 in., respectively. Obviously it is of the utmost importance that some means of at least roughly forecasting such variations be devised. At the very time that Weather Bureau forecasters are admitting inability to use past rainfall records as a guide in forecasting future rainfall, hydraulic engineers in southern California are forecasting a decade of abnormally wet weather, and they are making this forecast with no slight degree of confidence because they have discovered that during the past half century wet and dry periods of about 11 years have alternated.

Starting with this fact, the editor has been able to show that the pines of Arizona and the sequoias of California disclose this same sort of alternation with remarkable regularity, for 500 years in the case of the pines and for 3,125 years in the case of the sequoias. In the November issue of *Water Works and Sewerage* and in the present issue, the data supporting this important conclusion are given. By establishing the law that alternate wet and dry cycles of 11.2 years exist in California and Arizona, it can no longer be said that past rainfall records are never of any assistance in forcasting future rainfall. Relatively few scientific prognostications can muster a greater probability in their support than is now demonstrable in forecasting a relatively wet decade in southern California. The discovery of this law is alone sufficient to warrant confidence that other similar rainfall laws are discoverable. In fact, it is not the first discovery of an important rainfall cycle, for it was shown many years ago that certain areas are unusually wet during sunspot maxima whereas others are unusually dry at those times. But sunspot maxima were not predictable with much accuracy, although they usually occurred at intervals of about 11 years. The editor has found that Jupiter tends to produce a sunspot peak every 11.2 years, but that the magnetic effects of Uranus or Neptune may override it, the former every 81.1 years, and the latter every 161.4 years.

As we view it, the main trouble with our Weather Bureau is that it is a fact gathering organization that lacks an adequate research department. Without the latter, the facts that it has gathered have been put to little practical use. The money has been well spent in gathering weather data. Indeed, more money could have been spent to advantage. We do not criticize the Bureau on that score. We criticize it for its failure to make full use of the facts that it has gathered. Perhaps it has been supposed that somehow or other rainfall laws would gradually disclose themselves as rainfall data become more numerous, but scientific discoveries seldom discover themselves in that fashion. On the contrary, discoveries usually occur as a result of framing hypotheses to explain facts, followed by rigorously testing each hypothesis by an appeal to facts. This calls for scientific imagination and a training in research methods, which the routine collector of statistics seldom possesses.

Intead of fostering every effort to solve the rainfall problems, the heads of our Weather Bureau have been accustomed to belittle the efforts of other men, and have even refused to publish certain theories because they conflicted with those held by themselves. Yet what fruit has any one of their own theories ever borne? Not a bit that is of assistance to any farmer or to any hydraulic engineer. A person would naturally think that the owner of so fruitless a tree would at least welcome suggestions from any source as to how it might be fructified.

While it is somewhat premature to say that a definite relation exists between Alaska rainfall and that farther south on the Pacific coast, the editor has found that an abnormally rainy month in Juneau or Sitka is often followed, two to three months later, by an abnormally rainy month in central and southern California. Washington and Oregon show a shorter lag. Obviously this can not be due to the length of time required for storms originating near the Aleutian "low" to reach southern points, for storms ordinarily travel at railway speed. The cause of this phenomenon will be discussed in a later article. In October rainfall was 17.7 in. at Sitka and 17.3 in. at Juneau, or 65 and 45 per cent in excess of the averages for those months. This will probably be followed by abnormal rainfall to the south.

It seems not unlikely that rainfall near the permanent "lows" of the Aleutian Islands and Iceland can be used to forecast rainfall several weeks later at other parts of the earth. This suggestion may enable some hydraulic engineer to discover means of forecasting rainfall in certain areas. And while such short-time forecasts are of minor value to hydraulic engineers, if substantially correct they would serve to throw light on the phenomenon of rainfall. Next to nothing of engineering value is to be found in meteorological text books and journals as to the causes of periodicity in rainfall.

WATER & WORKS SEWERAGE

Design ~ Construction ~ Collection
Treatment ~ Distribution ~ Disposal

February, 1930 — H. P. Gillette Editor — Vol. LXXVII. No. 2

The Recently Completed Tirso Dam on the Island of Sardinia

Member A. B. C.

HEALTHY CITIES are PROSPEROUS CITIES

PROGRESS

1930 undoubtedly will record further progress in civic sanitation. One of the most significant trends is concerned with the treatment of sewage.

Here, as in other fields, Liquid Chlorine may be employed with advantage. While its use has passed the experimental stage, further extensive research studies are being conducted.

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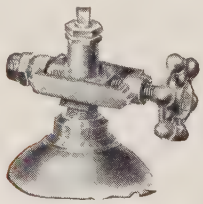

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Water Works and Sewerage

H. P. GILLETTE, Editor

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Vol. LXXVII FEBRUARY, 1930 No. 2

Revamping Old Sewage Treatment Plants

Utilization of Old Units in Modernized Plants Frequently Desirable—Methods and Examples of Conversion of Septic Tanks, Imhoff Tanks, Sand Filters and Trickling Filters

By FREDERICK G. NELSON

Sanitary Engineer, The Dorr Co., Inc., Chicago, Ill.

THE state of Iowa has approximately 213 cities and towns possessing sewage treatment plants. For preliminary treatment 121 have septic tanks, 89 Imhoff tanks and 3 separate sludge digestion. For secondary treatment 123 have intermittent sand filters, 54 trickling filters and 4 contact beds. Thirty-two have no secondary treatment.

The plants in Iowa are quite typical of the plants situated in the various other states. These are the types that are most generally met with when revamping old plants, and will therefore be given the most consideration in this discussion.

Use of Old Units.—Many of the plants listed above are still giving good service, but as time goes on an increasing number are becoming undercapacitated or antiquated. When this condition occurs the plant operators and engineers are faced with the problem of finding the best way of utilizing a portion of their existing plants and still allowing the new design to embody modern methods of sewage treatment.

Septic tanks are no longer considered in the design of new plants, except occasionally for very small ones. While they served a much needed purpose at the time they were being built extensively, they failed to meet the expectations of their advocates, and have given way to Imhoff tanks and separate sludge digestion.

Sand filters are still applicable for small plants, or where a large amount of natural sand is available, but are usually too expensive to consider for larger ones. The rate of application is so low that they require a very large area, and consequently a considerable outlay of money; the same results being obtainable at much less expense. Therefore it is necessary to revamp these existing units to fit into the new scheme.

Present practice tends toward separate sludge digestion or Imhoff tanks for preliminary treatment, and trickling filters or activated sludge for secondary treatment. It is the purpose of this paper to discuss in a general way the possibilities and various schemes which have been used in modernizing old units to conform to present practice. Many city officials are willing to make the necessary improvements if they can see a way of saving a portion of the money already invested in sewage treatment, and still get a modern up-to-date plant.

Old Septic Tanks Being Revamped for Aeration Tanks at Salem, Ohio

Problems Met in Revamping.—It is not possible in this space to discuss fully all problems encountered in the revamping of existing plants. Each job presents a different problem and will require special study before recommendations can be made. However, there are certain general features which should always be considered. This paper will discuss these general features, including several examples of plants which have actually been revamped.

In studying a sewage treatment problem where a plant already exists, probably the most important consideration is to decide on whether to utilize the existing site, or select an entirely new site. This decision will depend upon several considerations, such as (1) the natural features of the site—elevations, accessibility, distance to final disposal, etc.; (2) whether the old site is so situated that it will interfere with the natural growth of the city; (3) if there is sufficient area for future expansion of the plant; (4) comparative cost involved in the utilization of the old versus the selection of an entirely new site.

Assuming that, after giving due consideration to these various points, the old site is selected, it is then necessary to decide what portion of the old plant can be salvaged. There are three important points to consider before making the decision: (1) the cost of revamping a particular unit as compared to that of the new unit, (2) the serviceability of the completed plant

Salem, Ohio, Sewage Plant Before Revamping

and (3) the local political situation. Comparative costs can usually be worked out with considerable accuracy, but the serviceability of the completed plant is an entirely different problem. Unfortunately, experience has shown that engineers have too often allowed the cost to be the predominating factor in the design of sewage treatment plants, forgetting that if they do not obtain the desired results they have failed in their object. The first consideration should always be to design the plant to give the required results; secondly, the design should be made as economical as practical.

The local political situation becomes of importance sometimes in making the decision as to whether portions of the old plant will be utilized. If a bond issue is to be put over, it can often be made to carry over considerable opposition if the public knows that a large part of the existing plant can be salvaged, although it might actually involve slightly greater expense.

Conversion of Septic Tanks.—The most usual types of old plants encountered are those using either the single or two-story septic tanks for preliminary treatment, followed by either intermittent sand filters or trickling filters.

Single-story septic tanks are usually of such proportions that they offer several possibilities for converting into other units. They might be converted into one or more of the following units: (1) aeration tanks for the activated sludge process with either air or mechanical aeration, (2) clarifiers, (3) sludge digestion tanks, (4) sludge storage tanks or (5) left as septic tanks and used to treat storm flow.

Considering the case where the new plant is to be of the activated sludge type, it then becomes of importance to determine the comparative sizes of the old tank and that required for the new aeration units. Single-story septic tanks have been designed for detentions varying from four to six hours. While septic tanks have been given a greater detention than will be required for the new aeration tanks, this is usually compensated for by the increase in design population over what it was when the septic tanks were built. To illustrate, suppose an old septic tank had been designed for a detention period of twelve hours to accommodate a population of 5,000. The new aeration tank is to have a detention period of six hours, but assume that the design population has increased to 10,000 during the lapse of time. It will then be seen that the old septic tank is just the right size. This is the actual situation for many cities. Septic tanks have the further advantage of being comparatively shallow, not requiring a great deal of work to convert them to the proper depth of channel.

Many of the old tanks can be converted easily into clarifiers and sludge tanks. They have often been converted into clarifiers by the installation of equipment, or used as plain settling tanks with hopper bottoms. At certain plants one end of the tank has been rebuilt to accommodate a clarifier and the remaining portion used either for sludge digestion or storage. Where small tanks are encountered they can often be most economically utilized for sludge storage.

Use of Old Imhoff Tanks.—Imhoff tanks have less possibilities than the single-story septic tanks, and are usually suitable only for either sludge digestion or storage, or sedimentation. An excellent scheme which has been used at many plants is to utilize old Imhoff tanks for sludge storage and conditioning after the sludge has been digested in another tank. By using this scheme the latest practice in sludge digestion can be followed at a very low cost. Investigators have found that most of the gas from sludge digestion is given off very soon after the sludge is placed in the tank, but in this country it is impractical to discharge it on to the drying beds for about five months during the cold weather; therefore, it is seen that a large portion of the sludge digestion tank must be used only for sludge storage. For new plants it is customary to construct the sludge digestion tank large enough to hold this five months' accumulation, but a considerable saving can be made in the size of the digester unit and also in the heat required to keep the sludge at the optimum digestion temperature if the excess can be drawn off and stored in a separate tank. Very little odor results from this practice as the gas is practically all given off before the sludge is drawn to the storage tank.

Old Sand Filters.—Old sand filters are always of greater area than required for sludge drying beds. The most common practice has been to abandon a portion of the sand beds, keeping enough only for sludge drying purposes. However, a few engineers have put these old beds to good service by using them for secondary treatment of the excess storm flow.

This practice results in considerable saving in the construction of the secondary treatment unit which can be designed to take care of the dry weather flow only.

Trickling Filters.—The last case that has to be considered is the utilizing of existing trickling filters. This problem is quite different from those which have been considered, because trickling filters are not obsolete and can usually be made to fit in the new design. If space is available the problem is simply one of adding additional filter beds. Often space is not available and it is necessary to resort to a type of treatment that does not require as much area. The engineers at Decatur, Ill., solved this problem in a unique manner when their plant became overloaded as a result of a large volume of industrial waste being discharged into the sewers. After preliminary sedimentation the effluent is given a short period of aeration and then resettled; this effluent is dosed on the trickling filters at a relatively high rate.

Examples of Revamped Plants.—These various schemes which have been pointed out are well illustrated by the following plants which have recently been revamped. Salem, Ohio, furnishes a typical example of an old septic tank, intermittent sand filter plant being revamped to the activated sludge type. The old plant was designed and built

in 1912, and consisted of essentially three septic tanks, each 20 ft. by 90 ft. 6 in., with an effective depth of approximately 7½ ft.; intermittent sand filters and a chlorination basin. The new plant is of the separate sludge digestion, activated sludge type, and consists of a mechanically-cleaned bar screen; two 35-ft. clarifiers for settling activated sludge; one 50-ft. diameter sludge digester, equipped with mechanism and gas collection and heating features; one 18 ft. 6 in. by 10 ft. 6 in. deep sludge storage and conditioning tank, and a portion of the old sand beds used for sludge lagooning. The design was made on a basis of 15,000 population with an average dry-weather flow of 1.5 m.g.d. The sewers being of the separate system, the necessary changes were made in the septic tanks to convert them to aeration tanks. They were of such a size as to give a satisfactory detention of slightly greater than five hours for the average dry-weather flow.

The new plant at De Kalb, Ill., is a good example of an old septic tank being used for sludge storage. The old plant consisted of a septic tank 30x40x 10 ft. deep, and intermittent sand filters. The new plant is of the separate sludge digestion type, with trickling filters for secondary treatment, followed by final clarification. With a design population of approximately 16,000 the engineers used a 40-ft. diameter by 15-ft. effective depth sludge digestion tank, which gave slightly less than 1.2 cu. ft. per capita sludge capacity. This tank is equipped with a mechanism and provisions are made for heating and controlling the reaction so as to get a well-digested sludge in the minimum length of time. The digested sludge will be drawn at frequent intervals during the year and stored in the old septic tank until such time as it can be put on the drying beds. Considerable saving resulted in the cost of the digestion unit by using this scheme. Only a portion of the existing sand beds were required for sludge drying and the remainder were abandoned.

Princeton, Ill., affords another example of utilizing an old septic tank for digestion. The old plant consisted of a septic tank followed by trickling filters, while the new plant is of the separate sludge digestion type followed by activated sludge. The trickling filters were abandoned in the new layout, but the septic tank was remodeled for sludge digestion purposes, and new aeration tanks were built to accommodate Simplex aerators.

The plant at Lancaster, Wis., is similar to some of the plants already described. There were two existing septic tanks, portions of which were converted to aeration tanks for the activated sludge process, and the other parts converted to settling and sludge digestion tanks.

A small plant at Oconomowoc, Wis., had an existing septic tank. The new plant was designed for chemical precipitation, and a clarifier installed for removing the sludge which was pumped to the old tank for storage.

Barrington, Ill., had an old septic tank, intermittent sand filter type plant, while their new plant is of the Imhoff, trickling filter type. The old units were used to treat the excess storm flow. By using this scheme a saving resulted in the design of the new plant which only needed to be of sufficient size to treat the sanitary flow. The old units are not used frequently enough to cause an unsatisfactory condition about the plant.

The existing septic tank for a small plant at Rochelle, Ill., was rebuilt to form a sludge digestion tank for a separate sludge digestion, trickling filter type plant. A new plain hopper-bottomed settling tank was constructed.

Fostoria, Ohio, had an old Imhoff tank which was utilized in the design of their new separate sludge digestion plant. The flow-through compartment was removed and hot water coils were installed for heating the sludge.

When a new plant was designed for Fond du Lac, Wis., there was an old Imhoff tank in service, but the site was considered inadequate and an entirely new one chosen. The old tank is still in place and will probably be used at some time in the future for treating industrial wastes. The new plant is of the separate sludge digestion type with provision for gas collection and heating of the sludge. Provision has also been made for adding secondary treatment at such time as it is considered necessary.

There was a small Imhoff tank at Waukesha, Wis., but it was abandoned when a new site was chosen for the separate sludge digestion, trickling filter plant.

The design for the Jacob E. Decker & Sons plant at Mason City, Iowa, was an unusual case of plant revamping. The old plant was of the activated sludge type and consisted of a fine screen, a preliminary clarifier, aeration tanks and a secondary clarifier. The new plant is of the trickling filter type and consists of a fine screen, flow equalizing tank, preliminary clarifier, primary filter, intermediate clarifier, secondary filter and final clarifier. In the new design the fine screen was used as before. One aeration tank was converted to a storage tank for equalizing the flow, while the other is to be used for future sludge storage. The old final clarifier which had the required detention for preliminary clarification, in the new scheme, was used for that purpose. The air blowers were used in connection with the washing of the preliminary filter. All of these units fit in very nicely with the new layout.

Conclusions.—Of the eleven plants discussed, seven consisted of septic tanks, and three of Imhoff tanks for preliminary treatment. Those using secondary treatment had either intermittent sand or trickling filter beds.

In the new designs for the seven plants having old septic tanks, five were of the separate sludge digestion type, one was of the Imhoff tank type and one employed chemical precipitation with sludge storage and drying. For secondary treatment three used the activated sludge process and two adopted trickling filters, while two did not require secondary treatment.

Acknowledgment.—This paper was presented at the 11th Sewage Treatment Conference at Ames, Iowa.

Salem, Ohio, Sewage Plant After Revamping

Commercial Problems in the Water Business

By L. M. ANDERSON

Controller, Department of Water and Power, Los Angeles, Calif.

THE public relations and advertising divisions have their place in the water business, but nowhere can friends or foes be made so readily as in the commercial division, where periodical contract is necessarily had with the consumer.

The contract, as well as meter reading, collection and adjusting divisions, all have their important place in their relations with the public, who always expect the best treatment by the employees of the utility.

A Common Cause of Misunderstanding.—Every effort should be made to secure a signed contract for water service before the use begins. One of the great difficulties which tends to produce misunderstanding and ill feeling is that many will neglect to make application before beginning the use of the service. Someone will move from the premises without ordering a shut-off and a closing bill and a new customer will begin using water with no thought of making application therefor. The meter is read, the bill rendered under the old tenant's name and no attention is paid to it by the new tenant until a shut-off notice has been given, then the trouble begins.

If a guarantee deposit has been made by the previous tenant it is very easy to make a deduction from the deposit for the amount of the bill; if no deposit, then the only alternative is to proceed to collect from the new tenant who has substituted himself for the old one by using water without first making application and signing a contract.

Guarantee Deposits. — Requiring a guarantee deposit to secure the payment of water bills is important and requires discrimination without apparent favoritism.

It is good practice to require deposits in each case from renters, where the owner of the property will not sign a guarantee contract, and also from owners who are always in a chronic state of arrears.

Meters should be read for billing as nearly as possible each thirty days.

Prompt Rendering of Bills Important.—Meter readers should be trained to notice any great difference in present as against average readings. If there should be a noticeable difference in the consumption, whether more or less, and no apparent change in the use of water on the premises, it should be reported immediately so that an inspection can be made and the consumer notified if a leak exists, or perhaps the meter is not operating and requires overhauling.

Prompt notice of unusual bills saves many misunderstandings and if adjustment is to be made, it is better to do so immediately than to wait until some future time, when conditions may have changed sufficiently to make it next to impossible to arrive at a fair adjustment. Prompt rendering of bills is very important.

If there has been an excessive use and a large bill is the result, the consumer should receive his bill promptly, thereby giving him an opportunity to correct the trouble if it exists.

Making Adjustments.—Adjustments should not be made unless the large bill is the result of an accident or from some cause not under the user's control. If you begin to make adjustments and allow rebates, except for waste not under the control of the consumer, you will never know where to draw the line.

The person who insists upon a rebate and states that it is not the amount of money but the principle involved, is usually not sincere. More than likely the reduction in the bill is what he wants and he will be satisfied with nothing else.

Bills should be rendered promptly. The sooner a bill is in the hands of the average person, the sooner it will be paid. The longer the delay in getting bills out, the greater will be the loss from uncollectible bills.

Meter readings should be checked when extensions are made by the office force and bills made and mailed as soon as possible.

Adjustments should be made at the office whenever possible, as it is easier in most cases to come to an understanding there than at the home of the complainant. "A dog under his own wagon is hard to handle."

The selection of inspectors and adjusters should receive serious consideration. These men must be neat in appearance and should possess considerable poise and be of sound judgment. It will be part of their routine to stand abuse without retaliating.

Billing and Collecting.—Collections by mail are the cheapest, although collectors can hardly be dispensed with as a visit to the premises may be required in many cases when no reply is received from a mailed bill. The customer may be temporarily absent or there has been a change of tenants.

In case there is a new tenant, it is necessary to learn, if possible, the whereabouts of the previous tenant owing the bill, and also to have the new tenant sign up for the use of the water.

The stub bill system is very good for a follow-up of collections. If the bill is not paid in say, fifteen days after mailing, the delinquent stub can be detached and mailed or sent out by a collector. By this system it is only necessary to check over the unpaid accounts, which are readily seen, as the stubs on the paid bills are detached at the time the payment is posted and the unpaid ones only remain.

If the business is large enough and there are many accounts, the tabulating machine card system works admirably in checking unpaid accounts, as well as in many other particulars.

Charges for Unusual Items.—Charges for unusual items, such as damaged meters, and bills of that nature should be discussed with the person responsible for the damage and an understanding reached, if possible, before the bill is rendered. Otherwise a great deal of time is consumed and expense incurred before the bill is collected.

The regular monthly bills are not troublesome to collect, but those for the unusual items and for closing bills are hard to collect and expensive.

The consumers' bill should be simple, easily understood and without too much text.

The subject of district or sub-offices is always a problem in large communities.

The consumer cannot understand why an office should not be maintained in his locality for his convenience.

It is more efficient and economical to keep the accounts and bills at a central or general office, rather than to divide this work by doing some of it at a branch office. Just how much should be done at a branch or district office is a question.

It does not pay to maintain a very high priced, efficient force at a small office, but rather one understanding the detail of the business.

Whether anything more than taking orders and collecting bills should be done at a branch office is debatable.

It is difficult to obtain prompt reports of orders and collections unless a messenger service is maintained, and, if the territory covered by the utility is large, the expense of such service is out of proportion to the amount of business usually done at a branch office.

Much has been said regarding shut-offs for delinquent bills. It is difficult to establish an inflexible rule in this respect; there are so many exceptions worthy of consideration.

If it were possible to secure the proper legislation in this state making the charge for water a lien against the property served, there would be little necessity for shutting off water on account of delinquent bills. There is, however, quite a difference of opinion in regard to such legislation.

Acknowledgment.—The foregoing is a paper presented before the California Section of the American Water Works Association.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Filtration Engineer, Bureau of Engineering, Chicago, Ill.

Cracks in Filter Beds

NEARLY everyone operating a filter plant has observed cracks along the sidewalls of the sand beds. In addition to this, the surface cracks occasionally cover the entire filter bed, sometimes to the extent that there is scarcely a square inch of surface area that does not contain a crack. Sidewall cracks in many plants are readily noticeable at all times of the year, but the size of the cracks usually vary considerably for different seasons or for changes in the characteristics of the water. All filter beds have a tendency to pull away from the sidewalls as the loss of head increases if there is any shrinkage whatever of the beds. Perhaps it would be more correct to say the beds are pushed from the sidewalls, for this is what actually happens. Sometimes the cracks along the sidewalls are so small they are not readily noticeable and the operator may believe none are present, but in most instances there is at least a small crack.

Sidewall Cracks May Extend Nearly to the Gravel.—Filters will be found varying from no cracks to cracks along the sidewalls 1 to 1½ in. wide at the top. Where there is a wide crack the sand may be pushed away from the sidewall for a depth of 60 to 80 per cent of the total depth of the sand. This may be demonstrated by taking a thin piece of sheet iron and running it down between the sand and the sidewall. This pushing away from the sidewall, together with the surface cracks, may produce a new filtering surface within the cracks much greater than the original sand surface.

Shrinkage of Sand Beds Cause Cracks.—When cracks form it is evident there is shrinkage or settlement of the beds. In our discussion of the filter bed in the January, 1930, issue, it was stated that the sand, after being suspended during washing, settles about as loosely as is possible for it to be. Even with this looseness of the sand bed there is not much shrinkage during filtration when the sand is perfectly clean and free from coatings. Each grain touches other grains and there is no way of applying a pressure that will cause it to be forced together to any material extent. If the bed could be jarred or vibrated so as to produce a slight movement of the sand the grains would work together more tightly and form a lesser volume, but this is not practical nor necessary for filter beds.

Fig. 1—Settlement of Sand from Filter Bed by Compacting

Figure I illustrates how sand containing a coating may be compacted. All three tubes were filled with water, then the sand was allowed to drop into the tubes, displacing part of the water. The tubes were filled to the same level with sand. The one on the left was allowed to stand just as filled. The one in the middle was taken in the hands, held in a vertical position, and rolled in such a manner as to produce a slight movement of the sand grains. The rolling was continued for about 1 minute. The one on the right was rolled in the same manner as the center one, but in addition it was bumped by holding the tube in a vertical position and dropping it about ½ in. on a wooden surface. This compacted it just a little more than the center one. The tube on the right has a volume only 84 per cent of its volume before compacting. Clean sand of the same size could be compacted about 10 per cent by the same procedure. There is a difference of about 6 per cent in the looseness of settling of clean sand and sand with a coating. It so happens that this 6 per cent was approximately the actual shrinkage of the bed from which the sand was taken. Whether or not this is a factor that may be determined in like manner for all beds, the writer is unable to state.

A loss of head of 8 ft. over the initial loss produces a pressure of about 500 lb. per square foot on the bed. This is not much of a load, and we should expect clean sand to shrink very little under this pressure. One-eighth inch probably is about the maximum settling for a clean bed of sand of average size and 24 in. deep, consequently a coating on the sand grains is a prerequisite for cracks to form. It is well known that the sand grains in many filtration plants have a coating. The writer described the coating on the sand grains of the Baltimore Filtration Plant in 1924.* The coating on the Baltimore sand was so thick that removing the coating from a given volume of sand caused it to shrink about 16 per cent in volume for sand that was the average of the bed. For the finer sand near the surface, removing the coating caused it to shrink about 30 per cent in volume.

Coating on Sand Grains.—There was so much organic matter in the coating on the sand grains at Baltimore that a flame would come from a small amount of the coating inserted in a hot muffle furnace. The residue after ignition was largely silica, aluminum oxide, iron oxide, and manganese. Table I gives a mineral analysis of the coating.

Table I—Analysis of Coating from Sand Grains Where Beds Form Cracks

	Per cent
Loss on ignition, largely organic matter	30.1
Insoluble in HCl, largely SiO_2	20.2
Iron oxide, Fe_2O_3	6.4
Aluminum oxide, Al_2O_3	36.7
Manganese dioxide, MnO_2	6.1
Calcium oxide, CaO	.3
	99.8

The treatment of the water influences the composition of the coating, for all coatings will contain a large amount of the coagulant and other suspended matter. Silica and organic matter appear always to be present in considerable

*Baylis, John R. Sand-bed studies at Montebello water filters, Baltimore. Eng. News-Record, 92: 13, 516-22, March 27, 1924.

quantities in gelatinous coatings, and while much of this may come from the suspended matter, part of it may be due to growths on the sand grains. Most fairly hard coatings, except calcium carbonate coatings, which the writer has observed contain iron or manganese, frequently both. It is believed that the coagulant and silt is largely entrapped in the coating and that it does not form the bonding material. The precipitate in settling basins does not bind itself together very toughly, even though it may stand for years, and there is no reason to believe that this alone will build tough coatings on sand grains.

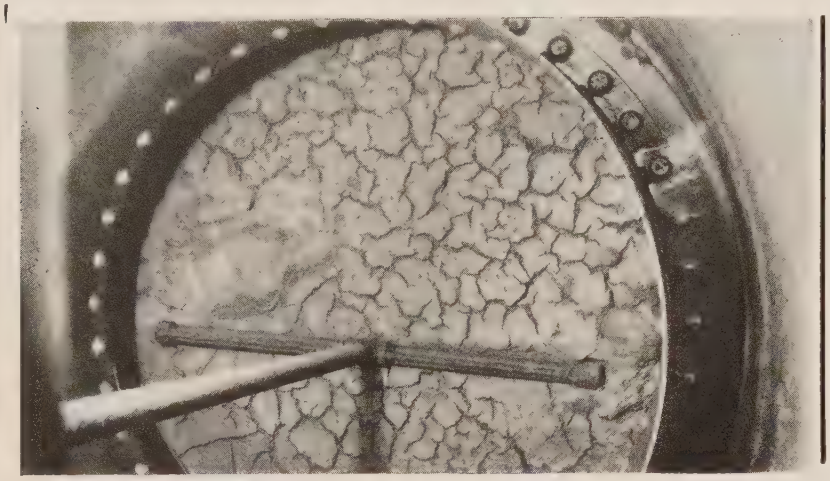


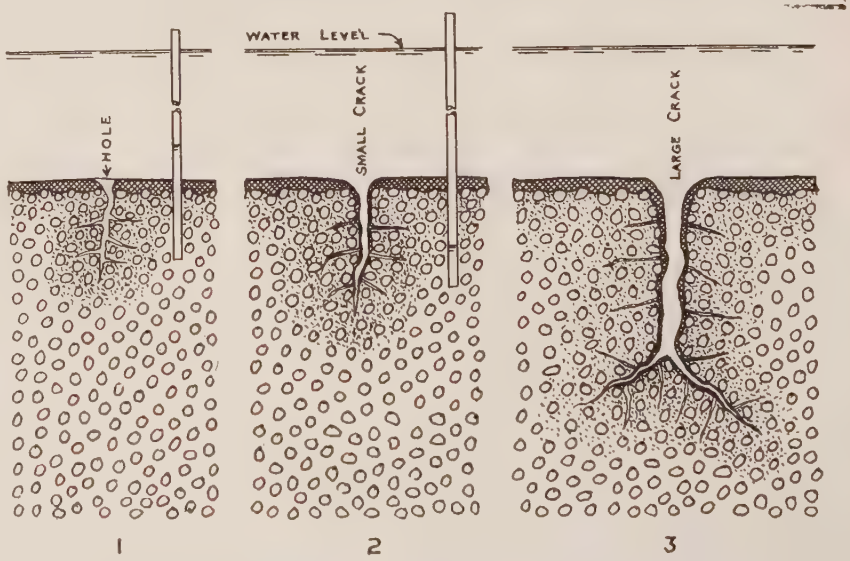
Fig. 2—Surface Cracks in a Small Filter Bed

Tough Coatings Build Up Slowly from Compounds Supersaturated in the Water.—Tough coatings build up slowly and more than likely are deposited from compounds supersaturated in the water. If there is a slight supersaturation of manganese in the water it will deposit on the sand surfaces, and once a coating has started the manganese will deposit more readily on the precipitated manganese and make the deposit thicker. Coatings built up in this manner are usually fairly tough. Should an iron compound be used to coagulate the water and conditions be favorable for complete precipitation of the iron, the precipitated material will not bind to the surfaces of sand grains. A slight amount of iron in solution, however, will cause iron to bind to the sand surface. The necessity for the binding materials in the coatings to come from compounds supersaturated in solution is illustrated by the formation of calcium carbonate coatings on sand grains in many softening plants. When calcium carbonate is precipitated from a hard water by the addition of lime, and after the precipitation has slowed up, the water is carbonated to where it is just saturated with calcium carbonate, it will not deposit on the sand grains regardless of how much of the precipitate may be carried on to the filters. If it is left supersaturated it will coat the grains with calcium carbonate, even if no precipitated material is left in the water as it goes to the filter beds.

Any solid exposed to water will, in most instances, eventually become coated with a slimy material. Most of us who have slipped on a submerged board or rock realize just how slippery a surface under water may become. The cause for the slimy coatings is not known definitely, but bacteriological or other biological growths are thought to be responsible. Such coatings usually contain considerable silica; however, biological growths may be the cause of the silica being deposited. It is known that diatoms have the power of precipitating silica to form a silicious shell. Whatever be the cause, gelatinous silica will deposit on most surfaces exposed to water. Sometimes it takes weeks or months for the coating to become thick enough to make the surface slippery to the touch; at other times only a few days are required. Occasionally the coating will form on surfaces exposed to water which has been chlorinated to the extent that it does not seem possible for bacteria to grow, indicating that biological growths on the surfaces are not necessary.

There is the same tendency for gelatinous coatings to form on the surfaces of the sand grains as on other surfaces, though washing usually keeps most of it rubbed off. The coarser the sand the greater is the abrasion during washing. This, probably, is why fine sand grains tend to coat more easily and more thickly than larger grains. Thick coatings usually do not form unless there is some material other than silica that binds the coating to the sand. This may be organic matter, iron, or manganese—sometimes all three. Wolman and Powell† probably were the first to attempt to explain the cause of cracks along the sidewalls of filter beds, though filter operators had been aware of cracks being present almost from the beginning of rapid sand filtration. They though that syneresis might offer an explanation of the shrinkage of the beds. The writer has never agreed with this view; however, this is of minor importance, for their article was a very valuable contribution to the literature on filtration. It inspired others to study filter beds, and we now know much more about the subject than we did 10 years ago.

Surface Cracks.—Surface cracks, as a rule, form only for short periods of time in most filtration plants. Very likely there are exceptions to the rule, but this is the case in all filters observed by the writer. Sometimes clogged places in the sand bed near the gravel will cause surface cracks to form when they otherwise would not and when there is no indication of the clogged area being present. In this



FORMATION OF SURFACE CRACKS IN FILTER BEDS

Fig. 3—Sketch Showing How Surface Cracks Form in Filter Beds

†Wolman, Abel, and Powell, S. T. The surface shrinkage of rapid filter sand beds. Eng. News-Record, 85: 5, p. 210, July 29, 1920.

case the cracks will be in certain spots and they will not cover the entire surface as is the case for the surface cracks now being discussed. Figure 2 gives a good illustration of the surface cracks in a small filter bed. The camera was pointed almost straight downward, and the photograph shows about what one sees when standing over a filter and looking down on the bed. The 1 in. pipe just above the sand surface gives some idea of the scale of the photograph. The pipe was placed there for a surface wash, but it had not been used prior to taking the photograph.

The writer has observed filter beds which run for months without surface cracks forming, then almost of a sudden they start forming. The condition shown in Fig. 2 may prevail for a month or more, then the cracks may stop forming and there may be another period of a few months in which none or only a few cracks form. Sometimes the surface becomes so badly cracked there is scarcely a square inch that does not contain a crack.

Surface cracks form when the coagulated matter is neither very weak nor very strong. It is, of course, essential that the filter bed shrink as the loss of head increases, for if this was not the case cracks could not form regardless of the strength of the coagulated matter. The toughness of the coagulated matter varies greatly in many waters from winter to summer. In winter the coagulated matter is frequently quite weak, penetrates deeply into the sand beds, and the filter runs are long. In the summer the coagulated matter is frequently very strong, there is practically no penetration, and the filter runs are short. Neither of these conditions produce surface cracks, it is the moderately strong coagulation that occurs frequently in the spring and in the fall that causes surface cracks to form.

This is apparently what happens when surface cracks form: The filtration is first largely in the surface layer. After the loss of head has increased 1 to 3 ft. over the initial loss, holes start forming through the surface. This was discussed and illustrated in the January, 1930, issue of *Water Works and Sewerage*. Sketch 1 of Fig. 3 also partially illustrates how the holes are formed through the sand surface. There is a rush of water through the holes, which starts branching off in every direction as soon as it passes the clogged area at the top of the bed. Where there has not been much penetration of the coagulated matter prior to the break the clogged area may not extend more than ¼ to ½ in. below the surface. Due to the high velocity of the water in the channels leading beneath the surface, most of the suspended matter is carried forward a slight distance before it is deposited, sometimes ½ in. or more. A clogged area is formed around the channel, and instead of the pressure being exerted on the area of the channel only it is exerted on an area frequently hundreds of times larger. The clogged area does not form a definitely defined spherical membrane with all the head exerted on the membrane, but the pressure head gradually diminishes through the sand in all directions from the channel. If there is a loss of head of 3 ft. over the initial loss before a crack forms, this head must be killed in some manner. One foot of this may be friction loss in the channel and branches of the channel before the area where most of the clogging takes places is reached. The other 2 ft. of head will be pushing sideways as well as downward on a clogged area that may equal the pressure on a hollow sphere 1 in. in diameter. Where shrinkage can take place in the sand, a pressure is finally reached that forces a crack in the sand. Once a crack starts it is easy for it to keep extending longer and deeper, due to the side pressure on the newly formed surface. There is the same tendency to force the sand apart and make wide cracks as there is to force the sand away from the sidewalls of the filter.

Sketch 2 in Fig. 3 shows about what takes place when a crack is first formed. It may open for a length of 1 in. or more on the surface and may extend ½ in. or more below the surface. The rush of water through the sides soon form clogged surfaces in the crack and the pressure opens the crack wider, deeper and longer. Sketch 3 in Fig. 3 shows a large crack that may be ¼ in. or more in width and may extend 2 to 4 in below the surface. This illustrates cracks about the size of the larger cracks in Fig. 2. The photograph in Fig. 4 shows some of the larger cracks to be fully ½ in. wide at the top. Some of these cracks extended a foot or more before running into other cracks started from other points. This is a condition when the coagulated matter is fairly tough and only a few cracks get started. If the coagulation had been weaker, there probably would not be 2 sq. in. of surface without a crack.

One condition very favorable for the formation of surface cracks is for the top 2 or 3 in. of sand to be more heavily coated with a gelatinous film, and to be more loosely packed than the balance of the bed. The first cracks that form are usually along the sidewalls and if the sand is of nearly equal looseness for the entire depth the side cracks may force the sand away from the sidewalls to the extent that they resist the formation of the surface cracks, especially in the area near the sidewalls. When the sand a few inches below the surface can be compacted or forced together only a very little the cracks along the sidewalls cannot open so wide. In other words, there is an unequal shrinkage of the sand at the surface and that a few inches below the surface. This is actually the condition in most rapid sand filter plants, for the smallest sand grains and those with the thickest gelatinous coating are the lightest and settle near the top of the bed after being suspended during washing.

If the formation of holes through the surface layer of the filter bed is an essential, we may ask why weakly formed coagulation does not produce cracks. There are so many holes through the surface in this case and they start forming at such a low loss of head that very little head builds up at any point in the bed. When the coagulation is tough practically all loss of head may be in the surface layer, but with the weak coagulation it may be a gradual loss through several inches of sand.

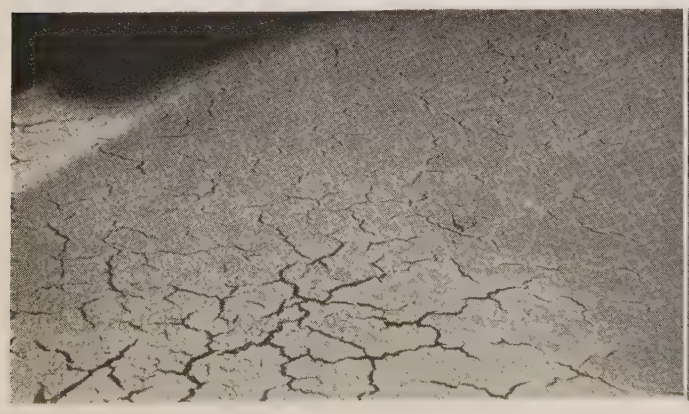


Fig. 4—Large Surface Cracks in a Filter Bed

Fig. 5—Flakes of the Surface Layer Not Broken Up by Washing

The writer has observed one condition that produces surface cracks when the flocculation is tough. This is shown in Fig. 5. Unfortunately the cracks do not show very well in the photograph, for the filter surface contained numerous cracks. The surface layer formed so toughly it was not entirely broken in pieces so small they were washed away when the filter was washed. There were pieces of the surface layer about ⅛ in. in thickness ranging in size from very small particles to flakes having an area of 3 to 4 sq. in. Most of these flakes remained on or near the surface of the sand. The flakes were left sticking into the sand in all directions, many of which were nearly at right angles to the sand surface with about one-half of the flake projecting above the sand. This is what shows most distinctly in Fig. 5. Where each flake projected through the sand, except where it lay nearly flat, a crack formed. The cracks always formed between the sand and the surface of the flake originally on top; that is, they never formed between the sand and the surface of the flake originally against the sand. The reason for this is not known. Somehow the newly formed surface layer would form a hole along this surface of the flake more easily than through other parts of the surface. This condition is believed to be very unusual and perhaps has not been observed by many.

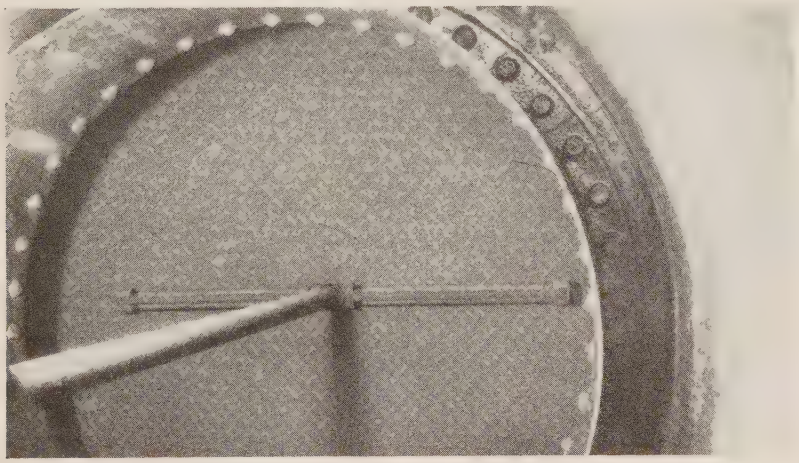


Fig. 6—Filter Bed After Using Surface Wash

Effect of Cracks on Filter Beds.—When cracks form the coagulated matter is usually so tough there is not much danger of the flocculated matter passing the sand beds, except along the sidewalls where the cracks are quite deep. In some instances cracks within or around clogged places also extend nearly to the gravel and may allow coagulated matter to pass the bed. The side cracks are much more dangerous than the surface cracks, for the surface cracks rarely extend more than 3 to 4 in. below the surface. Cracks lengthen the filter runs, for they produce a larger filtering surface. In some instances they may be regarded as being beneficial, for the filters do not have to be washed so often. They are believed to aid in the formation of clogged places by allowing large amounts of coagulated matter to concentrate at points beneath the top of the filter bed. This is especially true for cracks along the sidewalls. Clogged places are formed along the sidewalls of many filters, even when they do not form in other parts of the beds. In fact, very few filter beds will remain free from clogged places along the sidewalls all the time. The formation of clogged places will be discussed in a later issue. It is evident, however, that they should not be allowed to form and anything that will prevent their formation deserves serious consideration.

Cracks in filter beds may be eliminated or prevented from forming by keeping the sand grains so clean there will be practically no settlement of the bed as the loss of head increases. A surface wash appears to be the most practical means of keeping the sand clean all the time. This also will be discussed in a later issue. Compare the photograph in Fig. 6 with that of Fig. 2, and the value of the surface wash should be apparent. Fig. 6 is the same filter as shown in Fig. 2 after using the surface wash a few times.

Water Department Encourages Winter Construction.—The Water Department of Detroit, Mich., recently let a contract for laying about 9,000 ft. of 66-in. steel pipe, and in order to encourage the contractor to work all winter they are paying a premium of approximately 10 per cent of the contract price for each foot of pipe laid in the trench before April 1, 1930.

Small Cities in Kansas Have Water Systems.—Seventeen cities in Kansas, each of less than 300 population, have water systems. The smallest is Manter, population 148, which installed a $7,500 system in 1928.

Device for Sampling Sludge

An ingenious arrangement for securing samples of sludge from Imhoff tanks was used at the experimental sewage testing plant at the University of Illinois.

Samples of sludge were taken from a deep Imhoff tank and from a shallow Imhoff tank weekly and analyzed for bio-chemical oxygen demand, hydrogen demand, hydrogen-ion concentration, and per cent moisture content for the purpose of comparing the sludge from the deeper tank with that from the shallower tank in regard to these qualities.

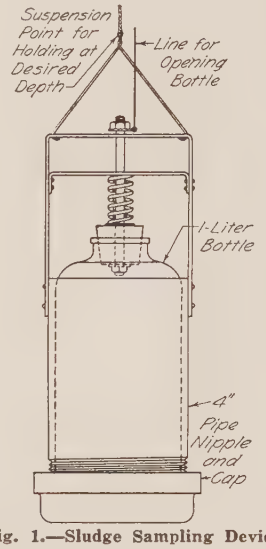


Fig. 1.—Sludge Sampling Device

The apparatus for the taking of sludge samples consisted of a wide-mouthed glass bottle of one liter capacity. The bottle was wedged within a 4-in. diameter pipe nipple. A wrought-iron cap screwed on the lower end of the nipple added sufficient weight to sink the bottle, and also served as a protection. The mouth of the bottle was closed by a rubber stopper held in place by a spring. The device is illustrated in Fig. 1.

In sampling, the bottle was lowered to the desired depth and the stopper was removed, by means of a chain, until the bottle was filled. The stopper was then allowed to spring back in position. The return of the stopper into the bottle made it possible to secure samples of sludge without the danger of introducing additional moisture into the sample as it was being drawn up.

Another device used for the taking of samples and for determining the sludge level consisted of an ordinary pitcher pump, on the suction side of which was attached a length of hose. The hose could be lowered to any desired depth and a sample taken by means of the pump. This device was especially useful in getting the sludge level due to the fact that the sludge was not disturbed when care was exercised in pumping and in lowering the hose.

Slag as a Medium in Sewage Trickling Filters

Results of an Inspection of Various Filters Together with a Suggested Specification for Blast Furnace Slag When Used in Filters

AN investigation of the use of crushed blast furnace slag in sewage trickling filters was made recently by Charles C. Hommon, Consulting Sanitary Engineer, Canton, O. The study covered 48 sewage filters, 37 of which had slag as the filtering medium. The results of the study have been set forth by Mr. Hommon in a report, which was published early this year by the National Slag Association. The following notes are taken from the report:

This investigation was made to determine the suitability of crushed blast furnace slag for use in sewage trickling filters. It is based upon the performance of all the slag trickling filters that could be located in this country. Thirty-eight such filters were visited together with eleven trickling filters in which aggregates other than slag were being used. The latter filters were inspected primarily for the purpose of making comparisons of the unloading ability of the different aggregates.

Unloading Ability.—With respect to the ability of crushed slag filtering material to unload, the inspection of the plants served to show that practically all of the older filters had retained a relatively large amount of organic matter. The same condition existed in filters containing other aggregates. In many instances, especially in the smaller plants, operating records were not available to indicate when and how completely the filters had unloaded. In others there was good evidence that the filters did unload at periodic intervals. These few instances of known unloading periods, together with the satisfactory operating records of practically all of the slag filters visited, indicate that the roughness of slag is not an important item insofar as the periodic sloughing of the organic deposits is concerned.

It is difficult even to estimate for comparative purposes the amount of organic solids contained in the many existing slag filters and in the filters filled with other types of aggregates. It may be said, however, that a great many of the older filter beds, regardless of the character of the medium, were dirty. Undoubtedly, all of the filters must have at least partially unloaded at periodic intervals, otherwise they would have become entirely clogged, but it appears that natural sloughing is not sufficient to maintain them in the best of condition in a majority of cases. Naturally, the load, character of sewage and other factors must be taken into consideration when comparing one filter with another, all of which render difficult the drawing of conclusions.

Control of Organic Deposits.—To determine whether or not it is possible to control the organic deposits that normally collect on sewage filters, considerable attention has been given to the operation of the filters at Canton, O. The two years of service has indicated that the slag filtering material will unload at indefinite intervals but that the deposits can be controlled within narrow limits (without lowering the efficiency in any respect) by (a) periodic resting and drying, or (b) flooding of the filters. It also appears that the use of chlorine will materially aid in causing the filters to slough.

Data on the efficiency of these beds while in a dirty condition are not available because of the care which has been exercised throughout the operation of the filters. It is therefore not possible to state the increase in efficiency that may have resulted from the cleanliness of the medium, but the entire absence of surface clogging (which is common in so many filters regardless of the type of filtering material) and the high degree of purification afforded the Canton sewage lead one to the conclusion that a clean filter is to be preferred to a dirty one.

More accurate determination of the unloading ability of the different aggregates and any advantages one material may have over another will require some research work through the use of a sectional test filter in which the different kinds of filtering material may be subjected to the same treatment.

Size of Aggregates.—Filters were found where the aggregate ranged from quite coarse to fine and all combinations of sizes were noted, sometimes within the same filter. In most instances where fine material was found the lack of evidence of disintegration strongly indicates that the fine material was placed in the filter at time of construction. This belief is strengthened by finding fine material in some of the newer filters where disintegration could not have played an important part, and it applies not only to slag but to other aggregates. One is therefore forced to the conclusion that sufficient attention has not been given to the inspection of the filtering material at the time of construction.

The surface slag in some of the filters as well as the surface stone in the limestone filters showed evidence of having failed to varying degrees. In the case of slag the failures were of three general classes, namely, flaking, splitting and disintegration, the former being the most common. The failures in the limestone filters were of two general types, namely splitting and disintegration, splitting being the more prevalent. It is not possible to state the degree of failure in definite terms because of the lack of knowledge concerning the original condition of the material; however, the fact that one of the older slag beds has a satisfactory service record of 21 years indicates that the failures have not been very serious.

Consolidation of Filtering Material.—Time would permit only a superficial examination to determine whether consolidation had occurred. That it had not occurred to any appreciable extent was indicated by the general appearance of the slag filters, the test pits that were dug, and the absence of any excessive clogging. In the few instances where slag filtering material had been removed, its condition indicated that consolidation had occurred only where excessive deposits of fine material existed. These areas (even though they had not solidified) would have become clogged and been rendered useless by organic deposits. Because of this fact the cementing action of slag is not considered a serious matter. There was no evidence found to indicate that slag reasonably free from dust and fines showed any tendency to cement.

It appears that development of the filter-moth fly (Psychoda alternata) is a logical occurrence in sewage trickling filters. They were found in varying numbers in practically all types of filtering material and had given rise to difficulties in beds filled with both rough and smooth aggregates, leading one to believe that the type of filtering material plays no part in their development.

Conclusions.—From the field investigation and from laboratory data the following conclusions may be justifiably drawn:

(1) The field investigation, in conjunction with sodium sulphate tests on samples collected from existing beds, show that crushed blast furnace slag is a durable material when employed as a sewage filtering medium.

(2) In a few of the filters, portions of the surface material had been affected by (a) flaking, (b) splitting and (c) true disintegration or crumbling.

(3) With the exception of 1 slag bed and 1 stone bed, this effect was not of sufficient magnitude to materially alter the size of the aggregate or affect operation of the filters. This conclusion is

based on the fact that few pieces of slag were found to have failed by true disintegration, and that the flaking resulted in only a negligible quantity of fine material.

(4) When exposed to air and sewage, individual pieces of slag containing much metallic iron may ultimately disintegrate, due presumably to the rusting and consequent expansion of the iron.

(5) Blast furnace slag as commonly used for sewage filters does not contain a sufficient amount of metallic iron to be objectionable.

(6) Improper sizing and gradation were found in all types of filtering material. Absolute adherence to correct size limitations will prevent such a condition.

(7) The efficient equipment now employed in preparing air-cooled slag is adequate to crush and screen the material so that it will meet any reasonable specifications.

(8) There was no evidence to indicate that crushed slag in the sizes now commonly specified for sewage filters will cement or consolidate.

(9) In the few instances where consolidation had occurred, it had been caused by excessive accumulations of fine material in localized areas, due to improper handling of the filtering material at time of constructing the filters.

(10) There is no greater amount of organic deposits retained in slag filters than in those filled with other types of material.

(11) The rough texture of blast furnace slag does not prevent the periodic unloading of filters.

(12) Laboratory tests in conjunction with the field survey show that the suitability of a slag filtering material can not be determined by any of the following factors: absorption, specific gravity, weight per cubic foot, loss by abrasion or chemical composition. It is also believed that hardness, toughness and cementing value have no bearing.

(13) Slag filters effect a very satisfactory stabilization of the organic compounds in sewage.

(14) It does not appear that the type of filtering material has any direct bearing upon development of the filter-moth fly.

(15) The field investigation indicated that sewage trickling filters (regardless of type of filtering material) would be benefited appreciably by controlling the amount of organic deposits retained in the filter. This can be accomplished by (a) periodic resting and drying, (b) flooding, or (c) chlorination.

(16) Finally, the information secured through this investigation indicates that crushed blast furnace slag is a suitable and desirable aggregate for use in sewage filters.

Factors Considered in Drawing Up Specifications for Slag Filtering Material.—This survey of sewage plants brought to light a number of details, apparently neglected at the time of construction, which have reacted detrimentally to the operation of the respective plants. Had a simple and efficient specification been prepared and strictly adhered to, it is believed that in many instances a more satisfactory filter would have resulted.

The following factors should not be considered as covering all the details to be provided for in a complete set of specifications governing the construction of a sewage filter. They apply only to the filtering material and the method of placing it in the bed. Some of the factors have been studied in the light of circumstantial evidence, and are therefore subject to revision as more evidence becomes available.

Important Factors:

The results of this study indicate that the following items are important factors in specifying slag as a sewage filtering material:

(1) The filter must at all times permit ready passage of the applied sewage and free circulation of air, and the medium should be of such size that it will afford the maximum surface area consistent with reasonable economy. It therefore follows that proper sizing and grading of the coarse aggregate are of paramount importance.

(2) The aggregate must be durable, otherwise the destructive effects of weathering, periodical wetting and drying, and freezing and thawing will cause disintegration, which, if in appreciable quantity, will result eventually in an unsatisfactory medium.

(3) The manner in which the aggregate breaks when crushed is also of importance, roughly cubical shapes being preferable.

(4) The method of placing the aggregate in the filters has a decided effect on later operation. If it is dumped in one spot and then distributed over the bed, fines will accumulate at that point, resulting in a tendency to clog the filter.

(5) The engineer in charge of the work and the producer furnishing the material must fully realize the importance of (a) absolute adherence to the specifications governing size of material, and (b) handling the material so as to prevent the formation of fines through breakage. If the aggregate is stock-piled at the disposal plant site, care must be taken so that, on re-handling, nothing but slag is placed in the filter.

For the reasons outlined above, it is believed that the items of durability, sizing and grading, cleanliness, and proper methods of placing the aggregate in the filter at time of construction will result in much improvement in work of this kind.

Unimportant Factors:

The following factors are believed to be unimportant in drawing up a specification for slag filtering material:

(1) Specific gravity, weight per cubic foot, absorption, resistance to abrasion, and chemical composition, for the reason that no relation was shown between these properties and the behavior of the aggregate in the beds.

(2) Toughness and hardness, since the aggregate is not subjected in a sewage bed to influences which would test these properties. The same applies to resistance to abrasion.

(3) Cementation, since cementation can occur only in material so finely-divided as to preclude its use in sewage filters.

(4) Surface Texture. Theoretically a rough material should be superior to a smooth one, since the rough surfaces afford better facilities for the attachment of finely-divided matter. Some engineers, however, believe that roughness tends to retain the solids to the point of causing excessive clogging. Practical experience does not support this belief, since (a) clogging was found with all types of aggregate, including ravel and traprock, and (b) satisfactory results have been obtained in practically all cases where rough aggregates have been employed.

Suggested Specifications for Blast Furnace Slag When Used as the Medium in Sewage Trickling Filters

Filtering material shall consist of crushed blast furnace slag having angular, roughly cubical fragments. The slag shall be furnished by a reputable producer fully equipped with crushing and screening facilities sufficient to assure the production of the material as specified and in such quantities as will be required for the prompt execution of the contract. A thorough inspection of the plant facilities and of the finished product shall be made by the engineer before final approval.

Sampling:

From the finished product (stockpile, bin or car) the engineer shall select for the required tests a representative sample of slag of the size to be used in the filters.

The slag shall meet the following requirements:

Durability:

The durability of the material shall be determined by 20 cycles of the sodium sulphate test prescribed by the American Association of State Highway Officials (U. S. Dept. of Agriculture Bulletin 1216, 9-28) except that the sample shall consist of 50 or more pieces of slag of the size to be used in the filters. The following conditions of test shall govern:

1. Any piece of the material shall be considered as having failed in the test which registers disintegration (a) By splitting into 3 or more pieces or (b) By crumbling to such an extent that there is 10 per cent fine material (by weight) passing the No. 4 sieve (sieve opening 0.187 in.).

2. Any sample registering failure in excess of 10 per cent of the pieces tested shall be considered of doubtful soundness and the test shall be repeated on a new sample. A second doubtful result will justify rejection of the material.

Metallic Iron:

All slag aggregate, after crushing, must be passed over a magnetic separator at the slag plant in order to remove pieces containing metallic iron.

Size and Gradation:

The material shall be graded within the following limits as indicated by round hole laboratory screens:

1¼ to 2½ in. size:	Passing 2½ in.	—95-100%.
	Passing 1¼ in.	— 0- 5%.
	Passing ¾ in.	— 0- 2%.
2½ to 3½ in. size:	Passing 3½ in.	—95-100%.
	Passing 2½ in.	— 0- 5%.
	Passing 1 in.	— 0- 2%.

NOTE: The 2½ to 3½ in. size is recommended, but the engineer may choose and write into his specifications either of the above sizes.

Method of Placing the Aggregate:

The material shall be placed in the filter in such a manner as to preclude (a) the formation of fines through breakage and (b) segregation through improper handling.

Coagulation Basins, Baldwin Filters, Cleveland

Design Provided Straight Flow Through Basins Without Baffles and Sharply Sloping Floors

THE coagulation basins of the recently completed Baldwin filtration plant of Cleveland, O., have a number of interesting features that are departures from ordinary practice. The provision of a straight flow through the basins with no baffles has proved entirely satisfactory. The use of a sharply sloping floor in the basins for the dual purpose of reducing the height of the outside walls and facilitating the cleaning of the basins also has proved to be of practical importance. A very complete description of the Baldwin filtration plant, written by Messrs. J. W. Ellms, G. W. Hamlin, A. G. Levy and J. E. A. Linders, appears in the February Proceedings of the American Society of Civil Engineers. That portion relating to the coagulation basins is reprinted herewith.

The coagulation basins shown in Fig. 1, extend for a distance of nearly 500 ft. from the east wall of Baldwin Reservoir. Data pertaining to these basins are given in Table I:

The four basins have an average water depth of 14 ft. 11 in., varying from a minimum of 9 ft. 4 in. to a maximum of 16 ft. 6 in. The water enters at one end of the basin over a weir and under a stilling-baffle and is taken off at the opposite end over a similar weir. Provisions have been made for by-passing the coagulation basins through a conduit along the west side of the basins, connecting Gate-Houses Nos. 1 and 6 (see Figs. 1 and 2). An inlet conduit forming the south wall of the basins furnishes the waterway through which the water flows to Gate-Houses Nos. 2 and 3. The former controls the flow to Basins 1 and 2, and the latter to Basins 3 and 4. There is one 60 by 84-in. sluice-gate for each basin. The control from the basins, at the outlet end, is effected through Gate-House No. 5 for Basins 1 and 2, and through Gate-House No. 4 for Basins 3 and 4. At the outlet end, there is one 60 by 84-in. sluice-gate for each basin.

The by-pass control of the coagulation basins is effected through Gate-Houses Nos. 1 and 6, where the water may be shut off entirely from the north and south conduits. When the by-pass is in use all the water flows through two 60 by 84-in. sluice-gates

Table I

Over-all area, in square feet, including conduits and gate-houses (457 ft. by 747 ft.)	341,379.00
Area, in square feet, between weirs inside of basins (108 ft. 7 in. by 661 ft. 6 in.):	
Basin No. 1	70,500.00
Basins Nos. 2, 3 and 4 (each)	70,900.00
Depth of water, in feet:	
Maximum	18.50
Minimum	9.30
Average	15.00
Capacity, in gallons, each basin	8,200,000.00
Detention period between weirs, in hours	4.70
Velocity of flow through basin, in feet per minute	2.36
Velocity of water in south conduit, in feet per second (water surface elevation, 242.5)	2.17
Velocity of water in north conduit, in feet per second (water surface elevation, 241.5)	2.42
Maximum velocity of water through sluice-gates (in feet per second)	2.43
Effluent and influent weirs:	
Maximum elevation	240.50
Minimum elevation	237.00
Length of weirs in each basin, in feet	77.00
Stilling-baffle:	
Elevation of top	242.50
Elevation of bottom	237.71
Overflow weirs:	
Length, in feet (each basin)	28.27
Depth, in feet, above weir to discharge 41,250,000 gal. daily (each basin)	0.77
Elevation of top	243.00
Elevation of floor:	
At center line	223.50
At sides	232.70
Elevation of flow line	242.00
Elevation of intrados at crown	245.50
Distance, in feet, from floor to crown of arch at the center of the basin	22.00
Total number of 20-in. square columns in the four basins, 15 ft. 9 in. on centers	1,041.00

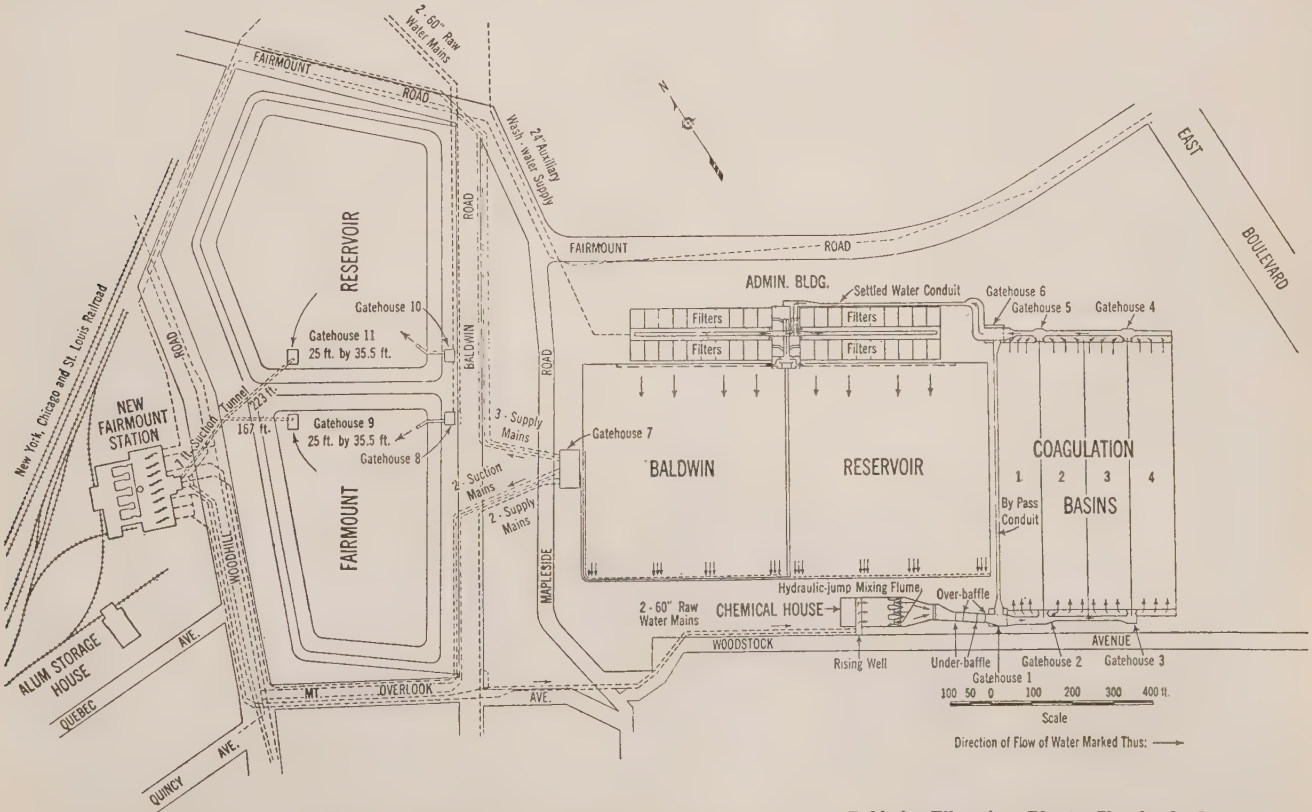


Fig. 1.—General Arrangement of Structures and Direction of Flow of Water at Baldwin Filtration Plant, Cleveland, O.

in each of the gate-houses. Under the condition of maximum flow, a velocity through these gates of about 3¾ ft. per sec. results.

Each basin is of reinforced concrete construction with groined arch roof, reinforced sloping floor, and independent column footings. The floor consists of two parts, a sub-floor 4 in. thick and a finished floor 8 in. thick, the latter being reinforced with ½-in. square deformed bars on 15-in. centers in both directions. The sub-floor butts against the walls and column bases. The finished floor rests on a ledge at the walls and at the column footings, and all floor joints are filled with asphalt to prevent leakage. The sloping floor performs the dual function of facilitating cleaning and of reducing the height of the wall sections.

All conduits (Fig. 2) were designed as rigid structures. Stability was investigated under conditions allowing an upward hydrostatic head of one-third the height of the water in the basin. In the case of the north conduit, recognition was taken of the possible removal of the earth backing at some future time to take care of adjacent construction, and the conduit was designed accordingly. At the by-pass conduit, the usual barrel arch was designed as a cantilever, extending from the roof of the conduit. Because of the frequency with which it has been observed that arch action does not always take place between the barrel and groined arches, all dividing walls between the basins were designed on the basis of an unbalanced arch thrust. The groined arches are tied together in groups of four and reinforced with two ½-in. square bars on either side of the crown. All manholes are tied securely to the groined arch roof with steel reinforcement extending well into the arches. This is required particularly in the case of the manholes supporting the mechanism for the mud-valves, in order to prevent frost action between the roof and manholes lifting the mud-valves off their seats in the floor of the basin, and thus permitting water to leak into the drains. The columns supporting the roof are of five different lengths, varying from 10 ft. 8 in. to 17 ft. 11 in. In the 10 ft. 8-in. and 12 ft. 8-in. columns, no reinforcement is used. The remaining columns are reinforced with four ¾-in. square bars, with ¼-in. round ties spaced 12 in. center to center. Six stiffening walls are placed in each basin, parallel to the long axis, and near the center of the basin.

Each coagulation basin is provided with six mud-valves for cleaning and draining. These valves permit flow into a lateral drain placed immediately under the floor of the basin and along the longitudinal axis. Each drain is connected into the main drain header near the north end of the basin.

To assist in cleaning, 2½-in. hose gates spaced about 50 ft. from center are provided on each side of each basin. They are connected to 6-in. water mains placed on the long walls of the basins.

Expansion joints are placed in the coagulation basin walls at intervals of approximately 60 ft. and at the junction of the walls with the gate-houses. The water-seal at these joints is made with a 16-in. strip of copper, approximately $\frac{1}{16}$-in. thick. About 7 in. of the strip is embedded in the concrete on each side of the joint with the remaining 2 in. formed into the shape of a V to provide for contraction. To permit expansion, the concrete surfaces at the joint are separated by ⅜ in. of asphaltic fiber cement. Subsoil drains, connected to the main drain, were laid under the floors of the basins and around the outside of the walls.

Meeting of New York State Sewage Works Association

The winter meeting of the New York State Sewage Works Association was held in New York City on Jan. 18, 1930. The program included an inspection of the 40 million gallons daily capacity sewage screening plant located beneath the surface of West and Marginal Sts. at Canal St., New York.

The attendance at the luncheon at the Hotel McAlpin was 89. There followed a very interesting technical program including talks on the sewage disposal problems of the Metropolitan District by Arthur S. Tuttle, W. W. Young and J. Ralph Van Duyne. Interesting round table discussions upon practical topics, including the pollution of beaches, dangerous wastes affecting sewers, curb and gutter inlets, tide gates, the desirability of sewers under each sidewalk and the handling of screenings, were led by Professor Earle B. Phelps, John F. Skinner, J. C. Collyer, John C. Riedel, J. F. Sanborn and H. B. Cleveland. The program was arranged by a committee headed by Richard Gould.

The president, Kenneth Allen, announced that the next meeting of the association will be the annual meeting and is scheduled to be held at Albany, N. Y., on May 10, 1930. He appointed Earl Devendorf, chairman of the committee on arrangements for this meeting.

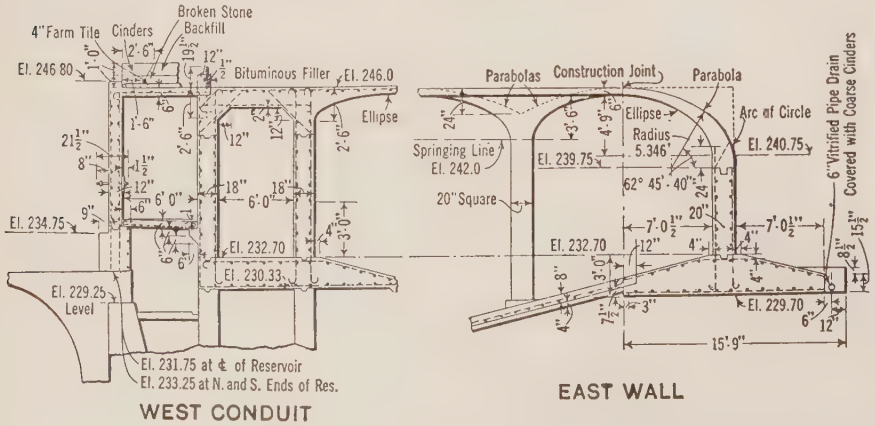


Fig. 2.—Coagulation Basins; Details of West Conduit and East Wall

Vegetation for Protection of Slopes from Erosion

The planting of slopes is recognized as a satisfactory means for protecting slopes against erosion. A. R. E. A. specifications for the use of vegetation for this purpose are given in the Manual as follows:

The slopes shall be graded to whatever final surface is desired.

Vegetation suited to the conditions existing in the territory where slopes are to be protected, shall be selected. This may consist of sod transferred from other locations; sod grown on slopes, as a result of seeding; vines such as honeysuckle, myrtle, etc., and dwarf species of shrubbery.

If the material of the slope is not fertile, it may be given a dressing of loam, manure or commercial fertilizer. As manure generally contains weed seeds, care must be taken, where applied, to prevent troublesome weeds from going to seed.

In order to prevent newly laid sod, transferred from other locations, from slipping, it is necessary to hold it to the slopes by use of wooden pins not less than 7 in. long, spaced not more than 2 ft. apart.

A good seed mixture for well watered parts of the country consists of about 50 per cent alfalfa, 25 per cent Kentucky blue grass and 25 per cent of red-top seed. Care must be taken to inoculate the alfalfa seed, if the soil has not previously grown alfalfa. Sweet clover is also effective at many locations, and in some sections of the country Bermuda grass is found to be best.

Honeysuckle vines are effective at many locations, the recommended spacing of plants being 2 ft. apart.

A Taxless City.—Colby, Kan., a municipality of 1,900 inhabitants, has been a taxless city since 1928 on account of profits from the municipal light and water plant. The surplus in the treasury at the present time amounts to about $49,000.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor
Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

Sludge Digestion

THERE seems to be so much misunderstanding about this matter of sludge digestion that we take this opportunity of restating a few homely facts with regard to the subject even at the risk of accusations of triteness or of carrying coals to New Castle. A mere codification of the essential known facts, shorn of scientific reservations and qualifications, should help to clarify the situation.

All living things consist of combinations of the elements, carbon, nitrogen, hydrogen, oxygen, together with smaller quantities of such elements as sulphur, phosphorous and lime.

Immediately life is extinguished in any such combination, or such a combination is excreted from a living organism, these elements become the prey of other living organisms which appropriate these elements to their own use by a process of selection either leaving free, or excreting in new combinations, such portions of the various elements as they can not use.

This appropriation of the elements to the maintenance or growth of living organisms is spoken of as a biological process as distinguished from purely chemical processes, such as the rusting of iron.

While all biological processes involve chemical reactions, the fact that disintegration of dead organic matter can be prevented by sterilization (the killing off of all living things which could come in contact therewith) is evidence that the disintegration of organic matter is essentially biological.

Such disintegration of organic matter in sewage is what we are interested in, and know as "Sludge Digestion."

The purpose of sludge digestion is to reduce the volume of waste material to be disposed of and to secure such combinations of the elements as will not produce objectionable odors.

The process is endless; the living organisms which make the original attack on the dead waste material in turn give up the ghost, and their elements are attacked by others which eventually die and are attacked and so on. Fortunately, about the time that the practical limit of shrinkage in volume has been reached the elements are arranged in non-odor producing groups which are more suitable to the maintenance of plant life than of animal life. Here the interest and responsibility of the operator ceases with turning over the residue to the agriculturist for use as a fertilizer, or to the bargeman.

What the operator is interested in is arriving at this stage in the shortest possible period of time, because the shorter the time the smaller need be the required storage space. Where the storage space for digesting material is limited (but not less than 40 times the volume of sludge collected daily), it is comparatively simple to keep the process in control under favorable conditions, but once the storage space is full before the proper stage of digestion is reached, troubles come thick and fast. Let us then investigate the subject of favorable conditions.

All organic material will eventually reach the desired stage even if left to itself under almost any conditions, but we have in mind one plant where the freshly settled sludge was pumped to tanks of some 20,000 cu. ft. capacity each, each tank being completely filled with the green sludge and left to itself. The result of such operation was, that digestion had made practically no progress at the end of two years. Such results, obtained at a time when the subject of sludge digestion was very poorly understood, gave "Separate Sludge Digestion" a reputation which it is very hard to overcome even with our present day information.

If spread in a thin layer, exposed to the atmosphere, the organic material which constitutes sewage solids would reach the desired stage of disintegration previously described by one route; if held in a large mass with the atmosphere entirely excluded it would arrive at an equally satisfactory stage of disintegration by another route. The first route is called the "Aerobic" digestion because the living organisms which make the attack require atmospheric oxygen for their existence. The second route is called the "Anaerobic" because the organisms involved do not require atmospheric oxygen.

If the material is in considerable bulk, yet with some of its surface exposed to the atmosphere, progress will be first by one route then by the other and much time will be lost. We must, then, determine on one route or the other and make every effort to keep the process moving in that direction.

The aerobic or atmospheric route is out of the question because its success would depend on spreading the material so thinly that unthinkable areas would be required and, obviously, the opportunity for spread of odors would be very great.

If, on the other hand, we adopt the anaerobic course, the depth at which we may store any part of the material is unlimited. We may therefore confine it within a reasonable area, an area so small that it is entirely feasible to cover the surface to protect it from the atmosphere, and we are then assured of uninterrupted progress toward a given end point by way of a predetermined route.

In all sewage there may be said to be two general classes of material; one consisting of paper and vegetable garbage in which the element carbon predominates, and one of animal origin in which the element nitrogen is the dominating influence.

The disintegrating organisms which normally predominate at the time when the sewage reaches the disposal plant are particularly aggressive in attacking the former class of material and any sulphur which may be available for their use. As a result the first evident effect of the attack is the arrangement of the elements carbon, hydrogen and oxygen into groups which constitute acids, of which the most familiar is carbonic acid. The sulphur also is arranged with hydrogen and oxygen to form acid, sulphuric acid, and with hydrogen alone to form hydrogen sulphide.

If allowed to remain in contact with the sludge these acids interrupt and slow up the process which we are attempting to hurry forward. If they are neutralized the elements which make them up become available as food for other organisms which will carry on the process.

It is also true that some of the organisms last mentioned combine the

elements in their waste products in such a way as to produce the alkali necessary to neutralize the acids, nitrogen uniting with hydrogen to form ammonia.

It is, then, only necessary to maintain a sufficient excess of old sludge (sludge which is being attacked by the ammonia producers) in order to provide automatic neutralization. With automatic neutralization the process is continuous and comparatively rapid.

Not only do the organisms attacking the older sludge produce ammonia as a by-product, but they also arrange a combination of carbon and hydrogen in the form of methane or marsh gas, a highly inflammable gas with a heating value about equal to that of the illuminating gas which we buy from the public service companies.

We know that at temperatures below 60° F. there is very little biological activity, in fact at 56° we enter the range of temperatures which electric refrigerator manufacturers refer to as the "Preserving Zone" because activity is so slow that food will keep for a long time below 56°. From 60° up to 82° activity increases very rapidly with each degree of increase in temperature and a biological process such as that in which we are interested will reach a given stage or end point in a correspondingly shorter time.

Now if, in the case cited, instead of pumping 20,000 cu. ft. of green sludge into an open tank and leaving it exposed to the air at whatever temperatures might be seasonable, the operator had known, and applied, the information here set forth the whole process would have been completed inside of 40 days instead of being barely started in two years time. In order to accomplish this very desirable end it would be necessary to:

(1) Add the fresh sludge gradually to older sludge on a fixed daily schedule, to keep the alkali producers in preponderance.

(2) Seal the surface of the sludge from contact with the air by covering to exclude both oxygen and cold.

(3) Make use of the inflammable gas, produced by the organisms, for the purpose of raising the temperature of the sludge to the point where the organisms are most active.

(4) When all of the preceding precautions have been taken, action becomes so violent that the evolved gas, passing upward through the mass, sets up a mild agitation which is beneficial in preventing isolated developments contrary to the general trend of the process and thus further speeds the process by perhaps 10 per cent.

As stated at the beginning of this article, we have, in the interest of clarity, foregone scientific reservations and qualifications. For instance, referring to the number (1) of requisites for rapid sludge digestion above, our scientific friends will doubtless rise up to state that, "To keep the alkali producers in preponderance" is only part of the story. This is true and it is equally true, that to encompass all the reservations and explanations would require another article as long as the present one, and so on with each of the other items until we should become befogged in a mist of words. We can only refer those who would dig deeper into the subject to the many excellent papers and books which are now available.

No distinction is here made between separate sludge digestion and digestion in Imhoff tanks or in septic tanks, because we are discussing the essential process involved and that is exactly the same in any of the three cases. However, because of lack of control, it is impossible to apply the information which we have at hand to the two latter.

Septic tanks have the advantage from the sludge end (but at the cost of the quality of the effluent) of disgorging much that would be digested with difficulty. Imhoff tanks, though designed expressly to eliminate this feature, retain it to a considerable extent.

We may collect gas from Imhoff tanks, but the nature of the gas vents, and their multiplicity, make this rather unsatisfactory, and it is entirely impractical to keep the floating solids in Imhoff gas vents submerged.

The temperature in the digestion compartment of Imhoff tanks is to a great extent governed by the ground temperature, and, in the Northern States at least, is down in the zone of preservation below 56° for a far greater portion of the year than it is above 60° F., where active digestion can be expected. Heating of the digestion compartments of Imhoff tanks would undoubtedly be very helpful if a practical method of application could be found.

The most favorable distribution of solids in an Imhoff tank by means of proportioning the velocity of flow of sewage somewhat to the area of the tank, is the nearest that we can approach to control of the old sludge-green sludge ratio in the case of such tanks. There are bound to be inequalities in deposition of sludge in tanks of such section and such inequalities lead to the setting up in isolated areas of a course of disintegration contrary to the general trend and, therefore detrimental.

From the above we see that it is only with separate sludge digestion that we can control and make optimum all of the conditions which are conducive to rapid odorless digestion, and that while exactly the same principles are involved in the case of double duty tanks we are almost helpless in their application.

With the English Sewage Works Managers

The 1928 Proceedings of the Association of Managers of Sewage Works (the latest yet available) contain various items which will be interesting to American plant operators.

Discussing sedimentation tanks, Mr. W. S. Jackson, River Inspector, West Riding Rivers Board, states that the general practice in design of sedimentation tanks of the continuous flow type is to make the width one-fourth the length but feels that better results would be obtained with the width one-third the length. This writer speaks very highly of a type of tank in which the flow is alternately under and over a series of baffles, stating that the flow is absolutely uniform. The sludge is collected in steep hopper bottoms and thus effectively removed out of the sedimentation zone, it is removed from the hoppers once or twice daily. He states that the only interruption of service of these tanks from "blockages" has been "due to some adventitious matter, such as buckets and bricks."

* * *

Mr. Walter Scott, speaking on the "Bulking of Activated Sludge," makes the following statements: "Bulking of sludge is not due to under-aeration or to over-aeration, since there is no difference in the D. O. in the effluent." . . . "A sludge which has got into the state known as bulking is equally efficacious as a purifying agent as a non-bulking sludge. The drawback is the difficulty in settling and the increased volume which have to be removed as surplus sludge."

"Bulking is due to the kind of material being treated"; milk wastes and starch wastes are particularly prone to bulk. In support of this statement he gives results of an experiment in which, sewage, sewage plus 1 per cent milk and sewage plus 1 per cent starch, were areated over a period of 27 days. Sludge volumes were read off daily after one hour sedimentation and the settled sludge made up to 500 cc. with the respective mixtures after the supernatant had been decanted.

Starting with from 13 to 14 per cent volume of solids; plain sewage increased in bulk of solids to 20 per cent on the 19th day where it remained, varying between 19 and 21 to the end of the experiment.

Starting at the same point, sewage plus 1 per cent milk grew to 47½ on the 17th day and jumped to 75 per cent on the 18th and after reduction to 19 per cent on the 18th day by dilution increased to 95 per cent on the 27th.

Starting likewise with sewage plus 1 per cent starch, the volume increased to 86½ on the 16th day and after reduction to 18 per cent by dilution on that day increased to 52 on the 25th, 90 on the 26th and 95 per cent on the 27th day.

Mr. Scott further states, "The chief

point of interest in treating tannery wastes is the instantaneous disappearance of tannin. We have found that with sewage containing 10 g.p.g. of tannin, the tannin immediately disappears on coming into contact with activated sludge, and on immediately filtering this mixture the filtrate is free from tannin."

* * *

For cleaning tanks which have to be drained for the removal of sludge the Proceedings describes a machine built on the lines of a diminutive road scraper and powered with a 1½ hp. gasoline motor.

Progress of the Federation of Sewage Works Associations

The Annual Meeting of the Board of Control of the Federation of Sewage Works Associations was held in New York City on Tuesday, Jan. 14th.

The reports of the secretary and of the business manager indicated progress for the Federation's first year far beyond what the most optimistic had dared to hope for.

The reports show that at the end of the year 1929 there were 13 active affiliated, sectional organizations with a combined membership of 1,081. Non-member subscriptions brought the total paid circulation of the Federation's Journal well above 1,200.

The surprising thing is that in one short year the Federation's Journal is on its feet, financially, the entire printing bill being met by the income from the Journal.

A resolution was passed in appreciation of the excellent work of the editor, Dr. Mohlman.

Another resolution was passed in appreciation of the work of the business manager, Mr. Wm. W. Buffum, and of the aid extended by the Chemical Foundation.

The great number of foreign subscriptions which have been received brought up the question of sections in foreign countries. Negotiations looking to the formation of a section or conference in Great Britain or some plan of affiliation with present British organizations was authorized as a result of numerous British inquiries along this line.

Water Power Development in Canada.—With the installation during the past year of new water power equipment totalling almost 378,000 H. P. there is now installed for all purposes a total of 5,727,162 H. P. and by the completion of work now under way this figure will be increased to more than 6,075,000 H. P. before the end of 1930 while an additional installation of over 3,000,000 H. P. is in active prospect.

Water Department Emergency Service Trucks

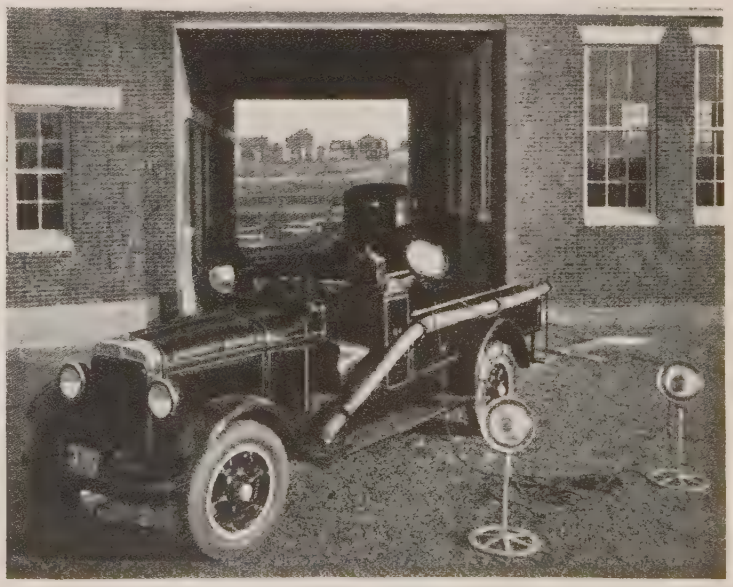
When the water works at Portland, Me., was taken over in 1907 by the Portland Water District the construction and maintenance work was being done by the use of three teams. Today, 18 automobiles and trucks are being used. The operation of this fleet has resulted in giving prompt attention to troubles and complaints. An important unit of this fleet is an emergency service truck, which is used especially for emergency troubles. The following description of this truck was given by James W. Graham, Treasurer and General Manager of the District, in a paper presented at the last annual meeting of the New England Water Works Association.

The truck consists of a 1¼-ton Graham Brothers truck. On each side is a tool box running the full length of the body, which also serves as a seat to carry extra workmen when necessary. In the tool boxes are carried implements such as picks, shovels, wrenches of various types, rubber coats and boots, gate books, electric hand lamps and extension cords, jacks, and tow lines. In fact, all tools necessary to handle water-works emergencies, such as breaks on main lines, distribution mains and hydrants, are included. The jacks and tow lines are used for assisting passenger automobiles, or trucks, which have become stuck in soft trenches or have run into open trenches. The truck is also equipped with a Kohler 2,000-watt automatic electric generating plant. The generator is capable of operating three 250-watt searchlights and several hand lights. It can also drive a ditch pump with a capacity of 70 g.p.m. against a head of 20 ft.

The truck is used for all emergency work and responds to all second-alarm fires within the territory supplied by the district for the purpose of closing gates in case of breaks on mains or hydrants. It also assists the fire department with flood lights when desired. In August, 1929, this truck responded to a general alarm fire where a loss of more than $500,000 was involved. For several hours its flood lights greatly assisted the firemen in their work. On several occasions the truck has been used on night emergency work, and the lights have greatly assisted our workmen. The total cost of the truck with equipment was $2,000.

Prompt Payment of Water Bills in New York City Required.—Two important changes in the law which shortens the time in which water bills in New York City must be paid have been made. Instead of being allowed three months from Jan. 1, property owners who pay on a frontage basis must now meet their bills by Jan. 31. Delinquents will be penalized 7 per cent on the bill from Jan. 1 to the date of payment, instead of the old graduated penalty of from 5 per cent to 15 per cent, which reached its maximum on June 30. Owners who pay on a meter basis must now meet their bills on or before the end of the month following the month in which the bill is sent, instead of the quarter following the quarter in which the bill was received. Penalties of 7 per cent will be charged against delinquents from the date of receipt. Bills received during the third and fourth quarters of this year may be paid without penalty up to Jan. 31, 1930.

Sewer Rental Rate in Ohio.—In 1928 there were seventeen cities in Ohio that financed the operation of their sewage disposal works by the sewer rental plan. The average minimum annual charge was $4 per sewer connection. Payment was usually made quarterly, as in rendering water bills.



Emergency Truck of Portland Water District

The Twelve Permanent Cyclones and Their Anticyclones

Weather Characteristics Explained by Electromagnetic Whirl Theory

By HALBERT P. GILLETTE

IN the October, 1928, issue of this magazine I presented an electron-whirl theory that explains many terrestrial and celestial phenomena. In that article I gave the location of the centers of 12 permanent cyclonic whirl-centers on the earth, and stated that each of these cyclonic whirls produces an anticyclone. I have made some minor changes in the location of a few of the mean positions of the centers of these 12 permanent cyclones, whose corrected positions are given in Table I.

As stated in my article a year ago, free electrons tend to rotate about magnetic lines of force, and if they exist in a fluid the fluid is propelled by the rotating electrons. The electrons in such whirls become concentrated so as to form whirling cylinders in which the electrons grow fewer in number as the center of the cylinder is approached. Hence, we may speak of cyclonic air-whirls as whirl-belts.

It should be added that all cyclonic whirls ascend, bend over and descend, forming an inverted U, and that they resemble a horse-shoe magnet, both as to shape and as to magnetic polarity. Looking at the two ends of a horse-shoe magnet, the north pole is where the electrons are rotating anticlockwise, and conversely as to the south pole.

The 3 permanent cyclones around the arctic circle rotate anticlockwise, whereas the 3 around the antarctic circle rotate clockwise. The same is true of the small migrating cyclones. In cross-section the cyclonic and anti-cyclonic whirl-belts are elliptical. The long axes of the 6 elliptical circum-polar cyclones lie nearly on the meridians, but somewhat inclined thereto; whereas the long axes of the 6 elliptical equatorial cyclones lie nearly on the lines of latitude. As a cyclone ascends the long axis of its ellipse turns slowly, so that by the time the air reaches the earth as an anticyclone that axis has turned through an angle of 30 to 45 degs.

It should be noted that the interior of a great whirl-belt, whether cyclone or anticyclone, is a place of relative calm, and consequently of small rainfall. The Sahara Desert, for example, lies within the largest and most powerful of the 12 great cyclones, A. Hence the Sahara is literally walled in by a hollow-cylinder of rotating electrons that prevent the entrance of moist sea air.

When the sun's north pole points most nearly earthward about Sept. 8, the 3 arctic whirls (a, b and c) are ordinarily most powerful, because electrons migrate to that region. Six months later (Mar. 8) the 3 antarctic whirls (d, e and f) are ordinarily most powerful. But the magnetic forces of the planets cause marked departures from these dates of major activity of the 6 whirls.

The four whirls nearest the equator (A, B, D and F) change their direction of rotation every 6 months; whereas the arctic whirls always rotate anticlockwise and the antarctic whirls rotate clockwise. The effects of these directions of rotation upon the general air currents will be discussed in a later article.

There are two great magnetic fields on all the planets and on the sun, an upper and a lower field. Each of these two "shells" of electrons contains at least 12 permanent whirls. The lower "shell" rotates rapidly with the planet's solid or liquid mass. The upper "shell" rotates very slowly and in the opposite direction to the rotation of the upper shell. It is the upper "shells" of the planets that cause most of the weather disturbances that are not purely seasonal. Sunspots aid in these non-seasonal disturbances, but are of less importance than the direct effect of the magnetic fields of the planets.

The reason for two layers or "shells" of free electrons in celestial bodies is this: Electrons are set free from atoms as temperature rises and as pressure falls. The highest temperatures and greatest pressures are near the center of a celestial body, whereas the lowest pressures and temperatures are remote from the center. The effect is to produce two shells of maximum density of electrons. In the earth the lower shell accounts for the ordinary magnetic effects on the compass needle, whereas the upper shell (Heaviside layer, 75 miles above the earth) accounts mainly for the earth's production of sunspots, and it also has a profound influence upon the migration of electrons and the generation of cyclonic storms.

Although there are several magnetic fields in each of the two shells of electrons (upper and lower), and although their relation to similar fields on the sun and planets affects the distribution of electrons in the earth and its atmosphere, which distribution in turn affects air movements and rainfall, still the weather problem is not made insuperably complex. By the electron-whirl theory I have been able to explain so many facts about weather, often quantitatively, that I am now convinced that it offers a means whereby the weather riddle, or rather congeries of riddles, can be completely solved.

In Encyclopedia Britannica, under Climate, will be found charts that show 3 of the 12 permanent cyclones of Table I and 6 anticyclones corresponding to the 6 circumpolar cyclones.

Charts of ocean currents show the mean positions of many of these permanent air whirls; the topography of the globe serves to locate every one of the centers of the 12 permanent cyclonic whirls, which are evidently the same for the molten matter beneath the earth's crust as for the air immediately above it.

Clayton's "World Weather," Huntington's "Earth and Sun" and his "Climatic Changes," and Brook's "Climate Through the Ages" all contain charts of permanent barometric highs and lows that will be found to be in accord, as far as they go, with the data given in Table I.

Table I.—Location of the Mean Centers of the 12 Permanent Cyclones

Center	Latitude Degrees	Longitude Degrees
A	17.5 N	0° W
B	17.5 N	120 E
C	40 N	132.5 W
D	2.5 S	67 W
E	29 S	145 E
F	10 S	135 W
a	66.5 N	180 W
b	66.5 N	30 W
c	66.5 N	75 E
d	66.5 S	135 W
e	66.5 S	30 W
f	66.5 S	75 E

Note: The symmetrical arrangement of these whirl centers is noteworthy, a hexagonal system being apparent.

Indiana Water Works Men Meet in March.—On account of the conflict with spring vacation at Purdue University the date of the meeting of the Indiana Section of the American Water Works Association has been changed to March 20 and 21. This meeting, as originally planned, will be held at Purdue University, Lafayette, Ind.

Los Angeles County to Store Excess Flood Water

Plan Would Cause Flooding of Large Acreage and Replenishment of Underground Reservoirs —Period of Wet Years Anticipated

A TOTAL of 22,500,000,000 gal. of water will be added daily during flood-water periods to Los Angeles county's naturally stored underground supply by the capture and infiltration of flood water that now runs off into the ocean and is lost, according to a plan proposed by E. C. Eaton, chief engineer of the Los Angeles County Flood Control District. The plan is described as follows in a recent issue of the Los Angeles Times.

The sinking process is through a system of confluent canals branching from main streams over adjacent spreading-grounds. The flood water is taken via one main or several canals from the river or wash conveying it and percolates partly through the canal bottoms and partly through the acreage over which it spreads from the canal ends, into the underground storage places. The system is so devised that certain canals can pick up the excess water spread by some of the ditches and direct it to other parts of the spreading-ground to expedite infiltration and prevent flooding. Where necessary, levees are located to protect roads and land adjacent to the spreading-grounds. The flood water is taken from the main streams at specified levels to prevent interference with the normal stream flow. Such a method, it is contended, not only will enable the desired infiltration but likewise will form a protection against flood-water damage.

If all of a single year's vagrant water in the county were put underground it would be enough to take care of the country's water needs for about three years, Mr. Eaton estimates.

As Water Reserve.—However, Mr. Eaton's plan does not intend a replenishment of the subsoil water supply in lieu of any of the pending projects to bring in additional water to this region from the Colorado River and other contemplated sources, but as an extensive water reserve or insurance while these projects are being consummated and after they are completed.

A preliminary suggestion in this connection has been submitted to the Board of County Supervisors by Mr. Eaton involving the use of unoccupied and untilled lands adjacent to several streams in the county as infiltration areas. This method is working successfully on 600 acres adjacent to the San Antonio River in the northeast part of the county, where it has been tried out to determine its feasibility for the entire county. Mr. Eaton expects to have the complete details of his plan worked out by July 1, next, as part of his new and comprehensive flood-control program including surface dams and other works that he considers essential.

Wet Years at Hand.—This is a particularly good time, he declares, to prepare for the underground replenishment because this county is about to have a new period of wet years in which the rainfall likely will be above normal. Such expectation is based on well-defined cycles indicating that several wet years follow eleven years or so of more or less subnormal precipitation here. In fourteen years there have been only two years of normal or super-normal runoff in this locality.

The water that wastes into the ocean is conveyed via stream channels that drain territory over which the flood water flows too rapidly or is of too great a quantity to permit of complete absorption. The larger part of the mountain drainage and the county's plateau uplands finds its outlet via the Los Angeles and San Gabriel River systems.

Extensive Reservoirs.—Conditions are

Method for Diverting Flood Water from Stream and Spreading It Over Infiltration Area

especially propitious here for underground water storage. Nature has given Los Angeles county the priceless boon of absorbent strata that form the largest and best natural subterranean reservoirs in the country. They have the additional advantage of natural underground clay dykes at their lower ends that are effectual dams and clay bottoms impervious to water. Throughout many years, these beneficently provided reservoirs have supplied an enormous amount of water for pumping and since 1904 there has been a progressive drop in the water plane.

Los Angeles county's geological history ascribes these reservoirs to a fortunate condition in sedimentary landmaking. An upheaval that brought the mountains at the north of the county into existence, is indicated. There is some belief that in unrecorded geological ages these mountains subsided and rose several times. Erosion carried earth and rocks from them toward the ocean, thus building up the Los Angeles plain and perhaps an upthrust along the plain's coastline aided this. Pressure upthrusts or faultline formation resulted in extensive dyke systems throughout this plain hedging in strata of gravel, boulders, sand and the like capable of enormous water storage so that these reservoirs or storage places underlie practically the entire plain.

Infiltration Areas.—It has been found that 2,500,000 or more gallons of water can be absorbed daily through every acre on which the flood water brought down by the rivers can be spread.

A natural dyke across the narrows of the San Gabriel River at El Monte makes all the flood water from the mouth of the canyon to El Monte, about ten miles, available for infiltration to the extent of 3,000 acres or more.

Approximately 2,000 acres contiguous to the Tujunga River are considered appropriate by Mr. Eaton as a spreading area, and about 1,500 acres at the San Antonio River. He estimates a total of about 9,000 acres in the county for such purpose.

Water Resources of Colorado River

The water resources of the Colorado River and its tributaries constitute the most valuable asset of a large part of the West and Southwest. With a view to determining the location, magnitude, and value of these resources, the Interior Department, through the Geological Survey, has for many years been carrying on investigations within the drainage basin of the river. Publications dealing with different parts of the basin have been issued from time to time, and the latest is Water-Supply Paper 617, entitled "Upper Colorado River and Its Utilization," by Robert Follansbee, which has just appeared. This paper, an elaborate report of nearly 400 pages which may be obtained from the Superintendent of Documents, Government Printing Office, for 65 ct., embraces the part of the drainage basin above the Green River.

The drainage area of this part of the basin is 26,500 square miles, which is 1 per cent of that above Lees Ferry, Ariz., the point that makes the dividing line between the upper and lower basins as defined by the "Colorado River compact," and the mean annual run-off is 6,600,000 acre-feet, or 45 per cent of that at Lees Ferry.

The report shows that in the area described about 564,000 acres is irrigated at present and that within possibly the next 50 years this area may be increased to 1,230,000 acres. The irrigation of the additional land will reduce the mean annual run-off by about 1,000,000 acre-feet.

The developed water power in this area amounts to 47,352 hp., divided between 41 plants. A historical sketch of this development discloses the fact that the first hydroelectric plant in the United States to transmit alternating current at high voltage for the purpose of operating a motor at a considerable distance is within this part of the Colorado River basin. This is the famous Ames plant, near Telluride, built about 1890. Another plant built about 1888 in this area was apparently the first in the world to operate an electric hoist for mining.

At 40 sites in the part of the basin above the Green River undeveloped power amounting to 117,000 hp. for 90 per cent of the time or 222,000 hp. for 50 per cent of the time has been considered. By the construction of storage reservoirs these totals would be increased to about 300,000 and 400,000 hp., respectively.

Transmountain diversions of water out of this part of the Colorado River basin now amount to 20,000 acre-feet annually, which may be increased to 300,000 acre-feet if additional projects described in the report are developed.

Wisconsin Water Supply Code Revised.—The Wisconsin public water supplies, sewerage and refuse disposal code has been revised to bring it up to date and incorporate new legislation and regulation. Tabulations are given in the code to show that 282 Wisconsin municipalities have public water supplies, excluding twelve supplies for fire protection only, and that 211 have public sewerage. There are ten municipalities with less than 500 population that have both water works and sewerage, and twenty-nine with water works only, while over one-half of the municipalities between 1,000 and 1,500 population have both, and one-fourth only water works. Two hundred eleven municipalities are equipped with public, and nine with semi-public sewerage systems, 127 of which are not provided with any form of sewage treatment to prevent stream pollution, the board reports.

Natural Purification in Polluted Waters

In the study of the pollution of streams the United States Public Health Service has directed considerable attention to the operation of natural processes in the purification of polluted water, especially the agencies and methods utilized by Nature in this process. In this intensive study it has been found that pollution (sewage, nonpoisonous industrial wastes, and similar polluting matter) when put into water, is immediately attacked by bacteria which are so small that at least two millions of them could rest comfortably, side by side, on the head of a common pin. These minute organisms find the pollutional material a satisfactory food and increase rapidly in numbers. By this feeding process, oxygen dissolved in the water is used up and the pollution is transformed into harmless bacterial bodies and by-products which are not putrescible.

At first it was believed that the bacteria, unassisted, could completely purify polluted water. This was found not to be the case, however. The bacteria multiply in the polluted water until a certain number of population is reached, the limiting number varying with the amount of pollution present. When the limiting population is reached, multiplication stops and the process of purification also stops, although considerable amounts of pollution may still be present. If the bacterial population of the water is reduced at this time, the multiplification and purification processes continue. To arrange for a continuous reduction of bacterial numbers, Nature, in her marvelous economic system, has provided some very small animals, called Protozoa, whose principal food appears to be bacteria. These bacteria-eaters, which are very much larger than bacteria, but yet so small that fifty of average size could lie on the head of a common pin, feed continuously on the bacteria and thereby prevent the bacterial population from ever reaching a limiting number.

In this manner Nature provides for the completion of the purification process, and the bacteria and the protozoa in the water decrease in numbers as the amount of food available for each decreases.

The addition of any poisonous substance to the polluted water may slow up or, if a sufficient amount be added, completely stop Nature's purification process, by killing off prematurely these industrious workmen.

A series of interesting papers describing the methods employed and the results obtained in these studies are being published in the Public Health Reports under the general heading of "Experimental Studies of Natural Purification in Polluted Waters."

Bleaching Powder as an Auxiliary Treatment of Sewage*

Experiences with Bleaching Powder (Chlorinated Lime) as an Adjunct to the Activated Sludge Process at a Sewage Disposal Plant in England

By HERBERT D. BELL

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IN introductory passages the author calls attention to the fact that he had applied bleaching powder as early as 1911 for odor control ahead of the sprinkling filters at Stratford-on-Avon, England, and that the process has continued in successful operation for the past 18 years. As early as 1914, while still in charge of that plant, all of the bleaching powder was applied to the crude sewage ahead of the settling tanks, such practice having proven by experience to be a more economical and effective odor control measure than was secured by applications to the tank effluent which was more septic than the crude sewage.

Bleaching Powder as an Adjunct to the Activated Sludge Process.—The Barnsley plant consists of two detritus tanks, two Dortmund type primary settling tanks and an aeration tank of 18 channels (Haworth method of bio-aeration) which provide a three-quarter mile travel of sewage. Agitation is supplied by 18 skeleton paddles. There are two final settling tanks of the Dortmund type. The plant, completed in December, 1924, had a designed capacity of 500,000 gal. per day (D.W.F.).

The sewage received at the works is mainly of domestic origin with some slaughterhouse wastes. During dry, warm weather the sewage is almost continuously septic upon arrival at the works and under these conditions heretofore the plant could only handle about 430,000 gal. per day, the remainder being pumped, at considerable expense, to a sprinkling filter plant for treatment.

In an endeavor to partially reduce the strength of the sewage delivered to the bio-aeration units during summer, "alumino-ferric" has been applied to the crude sewage to secure chemical precipitation in the primary settling tanks. Even with coagulant dosages varying between 3.5 and 6.0 grains per gallon pumping of sewage away from the plant had to be resorted to frequently.

The summer of 1929 was a particularly trying one in view of the increased strength of sewage caused by curtailment of water consumption in the town. In consequence of past experiences with bleaching powder at the Stratford-on-Avon plant, and thus appreciating its power to restrict septic action, it was decided to try the application of this chlorine compound to the crude sewage in place of the "alumino-ferric." It was also hoped that bleaching powder would check the tendencies toward putrefaction in the bio-aeration tanks and final settling tanks. Further than this, the satisfactory use of bleaching powder ahead of trickling filters suggested that not alone would its use probably reduce the plant loading, but it might assist the aerobic organisms and thus aid in increasing purification. Bleaching powder treatment was therefore commenced April 8, 1929.

The dosage applied to the crude sewage during the first 21 days corresponded to an average of 3.15 p.p.m. available chlorine (roughly 9.5 p.p.m. of bleaching powder). The results obtained from the beginning were distinctly encouraging. During the 21-day period no crude sewage had to be pumped away from the plant, no final effluent had failed to remain stable, and nitrate nitrogen appeared in the effluent. On the other hand, during the 36-day period prior to the use of the bleaching powder twelve average effluent samples had failed to remain non-putrefactive and there was no nitrate nitrogen present in the effluent during this period. In addition there had been 84 hours of pumping to reduce the sewage delivered to the bio-aeration units.

As a result of such encouraging performance the plant was equipped with more permanent apparatus for continuous feeding of bleaching powder solution to the crude sewage. The solutions were prepared from the plant effluent which absorbed some available chlorine. The available chlorine dosages will hereafter be referred to as calculated dosages which, because of chlorine losses through absorption by the organic matter in the effluent and in the form of spent sludge from the bleaching powder tanks, is obviously higher than was actually applied to the sewage.

For regulating the bleaching powder dosage the day was divided into four-hour periods. Each period was allotted a predetermined quantity of bleaching powder solution for application. The dosage was further varied to meet conditions, i. e., increased on days of high temperatures and absence of rain and reduced when these conditions improved. In arranging the dosages of bleaching powder it was later observed that economy and efficiency resulted if the additions were made in proportion to the strength of the sewage as well as the volume of flow. The calculated dosages of available chlorine employed during each 28-day period are shown in Table I.

Normally the Barnsley plant operates on the "fill and draw" principle. The results with bleaching powder having been so encouraging an attempt was made to operate on the "continuous flow" principle. The results were not as satisfactory, however, and the "fill and draw" process was resumed. In this the sludge in the final settling tanks is withdrawn completely five or six times each day.

It was decided that application of bleaching powder to that portion of humus (activated sludge) returned to the bio-aeration units might be reasonably expected to improve conditions further and also assist in the work being done by that applied to the crude sewage ahead of the primary settling tanks. During the discharge of the sludge from the final tanks the bleaching powder solution was added and this "fortifying" of the returned sludge was found very useful. The quantities of chlorine applied, calculated on the basis of the volume of returned sludge treat-

Table I. Sewage Volumes Treated and Chlorine Dosages Applied at the Barnsley Sewage Works, April 8-August 18, 1929

Period Ending	Gal. Sewage Treated	P.P.M. Available Chlorine Added		
		Crude Sewage	Humus	Whole*
April 28	9,076,000	3.94	0	3.94
May 26	13,071,000	3.54	0	3.54
June 23	12,058,000	9.74	18.23	10.36
July 21	12,544,000	12.94	16.86	14.29
August 18	13,704,000	9.64	29.17	11.69
Average		8.17	22.09	9.04*

*Read before The (British) Association of Managers of Sewage Disposal Works, Nov. 21, 1929, and herewith presented in abstract form.

*Note:—Calculated dosages arrived at from "whole treatment" is based on total volume of sewage treated and the total pounds of chlorine applied to the crude sewage and the returned sludge.

ed, are shown in the fourth column of Table I.

During the period Aug. 1-6 showery and cooler weather allowed the discontinuance of crude sewage chlorination, but it was found necessary to continue the applications to the sludge returned from the final tanks.

During the period of chlorination (April 8-Aug. 18) only three out of 105 samples of final effluent failed to remain non-putrefactive (stable). In one instance the unstable samples were caused by an unexpected increase of flow of strong sewage and were corrected by increasing the bleaching powder dosage. No pumping to reduce the flow was resorted to as would have been required under conditions of past summers and this represented the second instance of the power of bleaching powder to bring about a recovery of the bio-aeration process without reducing the flow of sewage handled.

In view of the fact that pumping sewage away from the plant to reduce the load constitutes an added operating expense at Barnsley, the over-all operating cost during the period of bleaching powder treatment in 1929 has proven to be less than that for the same period in 1928 when "aluminoferric" was being used and pumping resorted to when necessary.

In addition to the effects noted in conjunction with the bio-aeration process it was evident from the appearance of the sewage after addition of the bleaching powder that precipitation of certain solids was taking place in the primary tanks. It was therefore evident that the bleaching powder acted in a dual capacity.

The subsequent effect of the treatment on the detritus and primary tank sludges was marked, in that the primary sludge drained more rapidly than in previous years, and without odors being produced. The detritus sludge drained more rapidly, and with less odor than previously.

The Use of Bleaching Powder on Percolating Filters.—In an attempt to control the filter flies (Psychoda) at the trickling filter plant, bleaching powder solution was applied once weekly to the settled sewage. Monday mornings were selected as being the time during which the sewage received was the weakest and therefore the most appropriate time for the treatment.

Experimentation indicated that the most effective and economical dosage of bleaching powder was that which after a 20 minute period of contact insured the presence of residual chlorine in the applied sewage as it trickled over the stone beds. The bleaching powder was made into an emulsion in a barrel, the contents then being discharged at once to the sewage en route to the distributors on the filters. (The Barnsley percolating filters are circular and equipped with revolving distributors. There are no siphon tanks such as are employed with sprinkling fiters of American design.) The quantity of bleaching powder which produced the best results in connection with the Barnsley sewage was in the proportion of 15 lb. to each 100 ft. diameter unit, equivalent to approximately 85 lb. per acre. The weekly application to each unit resulted in a very much reduced fly population around the plant.

At the same time the numbers of the psychoda destroying springtail (Achorutus Viaticus) were apparently greater than in former years and the filter surfaces are all very clean.

Engineers Plan National Activity in Public Affairs During 1930

Selection of administrative officers to carry out plans for national activity in public affairs during 1930 are announced by the American Engineering Council. Major Gardner S. Williams of Ann Arbor, Mich., has been named acting president of the Council.

He will occupy the office until the return from a trip around the world of Carl E. Grunsky of San Francisco, former head of the American Society of Civil Engineers, who has been elected president for a two-year term, succeeding Arthur W. Berresford of New York.

Major Williams has been identified with the Council since its organization as the public service body of the engineering profession ten years ago under the headship of Herbert Hoover. Major Williams, a former professor in the University of Michigan, is a vice-president of the Council, and is chairman of its Committees on Government Reorganization and Flood Control. He is the representative on the Council of the Detroit Engineering Society, one of thirty national and local engineering organizations of which the Council is composed.

Following are the new members of the Administrative Board, the governing body of the Council, together with the constituent societies having a membership of 58,500 professional engineers which they represent:

American Institute of Electrical Engineers—C. O. Bickelhaupt, Atlanta, Ga.; H. A. Kidder, New York City; R. F. Schuchardt, Chicago; Prof. C. F. Scott, Yale University; C. Skinner, East Pittsburgh.

American Society of Civil Engineers—H. S. Crocker, Denver, Colo.; A. J. Dyer, Nashville, Tenn.; Anson Marston, Iowa State College; Frank M. Williams, Albany, N. Y.

American Society of Mechanical Engineers—Charles Piez, Chicago; John Lyle Harrington, Kansas City, Mo.; R. C. Marshall, Jr., Chicago; E. N. Trump, Syracuse, N. Y.; John H. Lawrence, New York City; D. Robert Yarnall, Philadelphia.

American Institute of Chemical Engineers—Dr. Harrison E. Howe, Washington.

American Institute of Consulting Engineers—Edwin F. Wendt, Washington.

American Society of Agricultural Engineers—Prof. William Boss, University of Minnesota.

Regional district members of the Board follow:

District No. 1, George A. Reed, Commissioner of Public Works, Montpelier, Vt., representing the Vermont Society of Engineers; District No. 2, Burritt A. Parks, Grand Rapids, Mich., Grand Rapids Engineers Club; District No. 3, J. S. Dodds, Ames, Ia., Iowa Engineering Society; District No. 4, C. B. Hawley, Washington, D. C., Washington Society of Engineers; District No. 5, A. A. Krieger, Louisville, Ky., Engineers and Architects Club of Louisville; District No. 6, W. W. Horner, St. Louis, Mo., Engineers Club of St. Louis.

1929 Meeting of New Jersey Sewage Works Association

The 15th annual meeting of the New Jersey Sewage Works Association will be held March 21 and 22 at the Hildebrecht Hotel, Trenton, N. J. The program includes the following:

Papers on Operating Experience by F. M. Veatch, Kansas City Mo.; Chas. Hommon, Canton, O.; Chas. Capen, Orange, N. J.; A. W. Dare, Bridgeton, N. J.

Drying Sludge Under Glass—Floyde G. Browne, Marion, O.

Drying Green Sludge for Fertilizer—Chester G. Wigley, Atlantic City.

Mosquito and Sewage Disposal—Ginsberg and Forman. Control of Breeding in Disposal Works—Lester Smith. Control of Breeding in Cesspools.

The New Plant at Red Bank—H. Burdett Cleveland, New York.

Experience with Activated Sludge—Maj. M. Blew, Philadelphia.

The Biology of Sewage Disposal—Dr. Houkalekien, New Brunswick, N. J.

Round Table Discussions—Odor Control, Operator Problems, Standard Greenhouse Construction, Suitable Paints, Suitable Pipe Construction, Sludge Drying.

J. R. Downes, Bound Brook, N. J., is secretary of the association.

Water Softening Plants in Ohio.—Four villages and one city installed water softening plants during 1929, making a total of 26 municipal plants in service in Ohio. The new plants are Crooksville, Gallipolis, Glouster, Marysville and St. Clairsville. The villages of Granville, New Bremen and Woodville have plants nearing completion which will be placed in operation shortly. Six of the eight new plants soften well water. Many other municipalities in Ohio are considering water softening.

The First Filter.—The first filter for a public water supply is stated to have been built in 1929 by James Simpson, engineer of the Chelsea Water Co., London, Eng. This filter merely served as a mechanical strainer for removing the turbidity from the water. It is reported to be still in service.

Gas Production from Imhoff Tanks

Results of Tests Conducted at an Experimental Sewage Tests Plant at the University of Illinois, Urbana, Ill.

A SERIES of tests conducted recently at the Engineering Experiment Station of the University of Illinois has brought out some interesting information on sewage treatment, particularly as relating to Imhoff tanks. The tests, which were made at an experimental plant at the station, were begun in June, 1925, and continued until June, 1929. They were made under the supervision of Harold E. Babbitt, Professor of Sanitary Engineering at the University. The results are set forth by Prof. Babbitt and Harry E. Schleng, Research Graduate Assistant in Civil Engineering, in a bulletin issued recently by the Engineering Experiment Station. The following notes on gas production are taken from the bulletin.

Tests were conducted on the Imhoff tank, for the purpose of determining the quality and quantity of gas produced in an Imhoff tank.

The tests on the factors governing the production of gas in an Imhoff tank were divided into two parts; one in which the temperature of the sludge-digestion chamber of the tank was not calculated from the sludge level in the tank, which was determined weekly. In the first part of the tests the temperature of the sludge-digestion compartment was determined semi-weekly. When the heating system was put into operation, the temperatures at five different depths in the tank were taken by means of bottles filled with clear water. These bottles were suspended at different points along a chain and were drawn to the surface for readings. The temperature of each bottle was taken three times a day to assure the proper temperature control of the heating unit. The hydrogen-ion concentration of the sludge in the tank was determined weekly.

Results of Tests.—Average values for the gas production, the temperature of the sludge compartment, the hydrogen-ion concentration, and the volume of sludge in the tank during the first part of the test in which the temperature was not controlled are shown graphically in Fig. 2. The observation of the rate of building up of sludge in tank was made possible because only a small amount of sludge was used for seeding. This rate is shown graphically in Fig. 2. The relation between the amount of gas produced and the volume of sludge in the sludge compartment is well demonstrated because other conditions such as hydrogen-ion concentration and temperature of the sludge compartment were approximately constant during this period.

The average flow of gas for the entire period of the test was 46.6 cu. ft. per 24 hours, or, on a basis of a flow of sewage of 19,500 gal. per day, it was 2,380 cu. ft. per million gallons of sewage. According to the figures of the Sanitary District of Champaign and Urbana, the average sewage flow is 3,500,000 gal. per day, computed on a yearly flow basis. The population of the city of Champaign is 24,000 and that of Urbana is 14,000. The student body of the University of Illinois of 10,000 is in attendance but nine months of the year, making a tributary population of 7,500 persons on a yearly basis. The total tributary population is, therefore, equivalent to 45,500, making a yearly average of about 80 gal. of sewage per capita per day. Using this figure the average flow of gas would be 0.298 cu. ft. per capita per day. Dr. Karl Imhoff obtained the figure of 0.3 cu. ft. per capita per day as the average gas production from Imhoff tanks in the Emscher District in Germany from an ordinary domestic sewage.

After the installation of the hot-water circulating system for controlling the temperature of the sludge-digestion compartment, it was possible to obtain slightly higher temperatures that were obtained in the previous period. However, it was found that the maximum temperature that could be obtained in the sludge chamber with the heating apparatus on hand was about 24° C. This was due to the constant cooling effect of the sewage passing through the tank.

The temperature of the sludge compartment was gradually increased to the maximum value possible with the apparatus on hand, and then allowed to fall. The relation between the amount of gas produced and the temperature of the sludge-digestion chamber is well demonstrated because other conditions such as the volume of sludge in the tank and the hydrogen-ion concentration were approximately constant during this period.

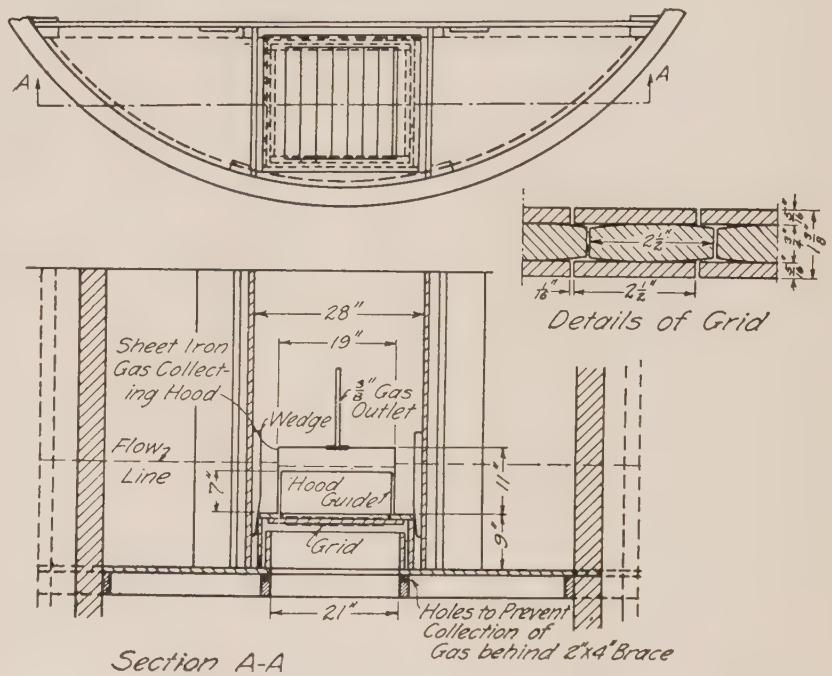

Fig. 1.—Details of Gas Collecting Apparatus.

Quality of Gas Produced.—Analyses of the gas produced were made occasionally, an Illinois gas apparatus being used. The results of the gas analyses obtained in these tests are given in Table I.

The presence of oxygen is believed to be due to air contamination of the samples.

Conclusions.—From the results of tests on the production of gas in an Imhoff tank the following facts have been demonstrated:

(1) The amount of gas produced in an Imhoff tank increases with an increase in the amount of sludge accumulating in the tank, this fact being especially noticeable when the tank is first seeded (see Fig. 1).

(2) The temperature of the sludge-digestion chamber has a marked effect upon the gas production, the gas production increasing with an increase in

Table I.—Analyses of Imhoff Tank Gas.

Date	Source	Composition in Per Cent CO_2	O_2	H_2	CH_4	N_2
June 21, 1926	East Vent	11.8	1.2	4.6	70.20	12.20
	West Vent	9.6	1.0	0.0	66.15	23.25
February 7, 1927	East Vent	15.3	0.4	1.3	63.30	3.70
February 24, 1927	East Vent	10.8	2.6	1.2	61.10	13.90
April 6, 1927	East Vent	4.5	0.9	2.0	73.70	15.30
Average		10.4	0.8	1.8	66.89	13.67

temperature. It was not possible to obtain temperatures higher than 24° C. with the apparatus on hand, so that the upper limit of this relationship could not be determined.

(3) The grids placed under the gas collecting hoods are quite effective in preventing the formation of a heavy scum at this point. This is probably due to the fact that the grids are submerged, which causes the scum to remain moist while its gas is being liberated. After the gas has been liberated the material gradually sinks to the bottom of the tank.

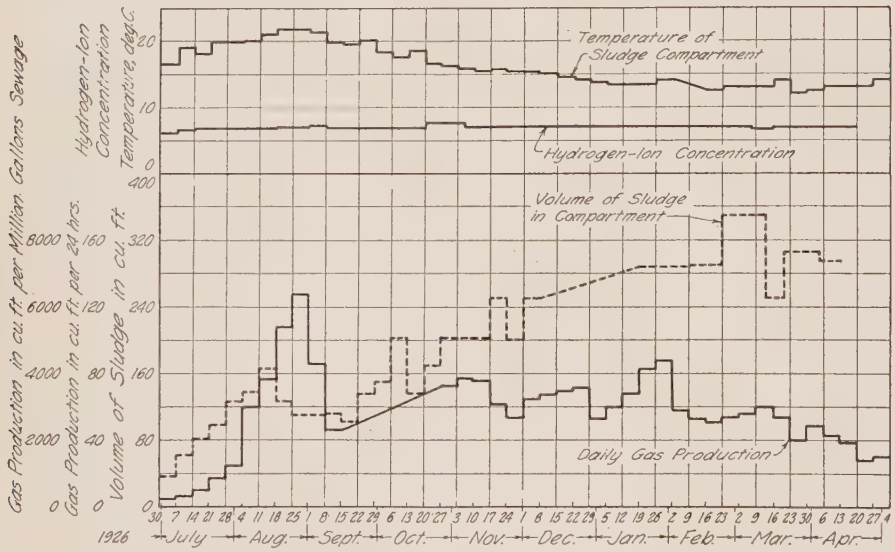

Fig. 2.—Weekly Averages of Imhoff Tank Gas Production.

(4) The average quantity of gas obtained from the Champaign sewage, an ordinary domestic sewage, was about 0.3 cu. ft. per capita per day. This amount of gas would not appear to be sufficient to warrant its collection and distribution as a public gas supply. It might be feasible to utilize the gas for fuel purposes about a sewage treatment plant, and to aid in keeping the temperature of the tanks at least up to the temperature of the incoming sewage in the colder months.

(5) It is not practicable to heat the sludge-digestion chamber of an Imhoff tank above the temperature of the incoming sewage for the following reasons:

(a) The amount of heat lost by the flow of sewage through the tank is so great as to prevent the heating of the sludge chamber beyond a certain temperature depending upon the temperature of the incoming sewage. With the type of heating unit used it was not possible to raise the temperature of the sludge-digestion chamber above 24° C., while the temperature of the effluent from the tank was, on the average, 10° C. higher than the influent. Since the average flow through the tank was 13.5 gal. per minute, this would mean a loss of 2,020 B.t.u. per minute or 149,000,000 B.t.u. per million gallons of sewage from this source alone.

(b) In order to offset the loss of heat due to the passage of the sewage through the tank, the temperature of the heating coils would be so great as to cause the sludge in close proximity to be heated excessively, and thereby digestion might be inhibited.

(c) When the sludge digestion chamber is heated above the temperature of the sewage in the flowing-through chamber convection currents are set up through the slot with resulting disturbance of sedimentation.

Cost of Engineering, Large Dam and Reservoir

Figures on the cost of engineering on the O'Shaughnessy dam and reservoir of the city of Columbus, Ohio, are given in a paper by John H. Gregory, C. B. Hoover and C. B. Cornell, presented before the American Society of Civil Engineers. These costs are set forth in Table I, accompanying.

It will be noticed that the percentages in this table are based upon a construction cost which covers other items than the cost of the dam and reservoir. This is because other engineering work was being designed and constructed under the supervision of the organization in charge of the design and construction of the dam at the same time that work was being carried out. In spite of the fact that each engineering assistant was required to keep a record of his time, it would have been exceedingly difficult to distribute accurately the total cost of engineering during this period to the dam and reservoir and to this other work. General expenses and the cost of supplies could not have been assigned with accuracy.

The work carried out by the department during this period, however, all consisted of some kind of water-works construction. The chief items were the enlargement of the water-purification works and the laying of additional cast-iron mains. As shown, the total cost of all this work was $3,217,440 and the cost of engineering applying thereto was $324,810, or 10.10 per cent of the total construction cost. A distribution of engineering costs is given in Table I.

The cost of the dam and reservoir per 1,000,000 gal., subdivided under cost of land, dam and reservoir, is given in Table II. The difference between the unit-cost based on available capacity and that based on total capacity is about 1 per cent. The costs in Table II do not include the cost of engineering.

Table I—Cost of Engineering, O'Shaughnessy Dam and Reservoir and Other Works

Items	Cost	Percentage based on total cost of construction of $3,217,440
Construction:		
O'Shaughnessy dam and Reservoir	$2,220,080	69.00
Enlargement of water-purification works	397,140	12.34
Cast-iron force mains	560,920	17.44
Cast-iron distribution mains	34,050	1.06
Miscellaneous	5,250	0.16
Total cost of construction	$3,217,440	100.00
Engineering:		
Borings and sub-surface investigations	$ 10,800	0.34
Pay-roll	271,280	8.43
Supplies	11,110	0.35
Expenses	31,620	0.98
Total cost of engineering	$ 324,810	10.10
Summary:		
Construction	$3,217,440	100.00
Engineering	324,810	10.10
Total cost	$3,542,250	110.10

Table II—Cost per 1,000,000 Gal., O'Shaughnessy Dam and Reservoir

Items	Total cost	Cost per 1,000,000 Gal. Total capacity, 5,400,000,000 gal.	Available capacity, 5,341,000,000 gal.
Land	$ 290,130	$ 54	$ 54
Dam	1,146,970	212	215
Reservoir	782,980	145	147
Total, exclusive of engineering	$2,220,080	$411	$416

Water Works in Kansas.—On Jan. 1, 1923, there were 261 water works in Kansas; on July 1, 1925, 264; on July 1, 1927, 283, and on Oct. 1, 1929, 308.

The Combined Operation of Water and Light Plants

An Interesting Discussion on the Advantages and Disadvantages Based on Conditions Obtaining at the Combined Plant of Kansas City, Kan.

By J. D. DONOVAN

Manager of Production and Distribution, Board of Public Utilities, Kansas City, Kan.

IN discussing the advantages and disadvantages of the combined operation of water and light plants the following observations are based primarily on a water plant deriving its source of supply from open water courses, and a light plant using in connection with steam driven prime movers, surface condensers, and they for the most part refer particularly to the writer's experience in the combined operation of the Kansas City, Kan., water and electric light plant. It is not intended to leave the impression that this set of conditions are necessary to obtain all of the advantages that can be gained from combined operation but they are mentioned on account of their direct bearing on the production department more than for any other reason.

Joint Use of Investment.—Foremost among the advantages of combined operation is the matter of investment required in certain of the physical properties such as land, buildings and warehouses, as well as the minor investment in certain forms of auxiliary apparatus together with tools and miscellaneous equipment. In the Kansas City, Kan., plant there is, for instance, an intake well located within the harbor lines of the Missouri River having a maximum capacity of approximately 100,000,000 gal. daily, this well being fitted with revolving trash screens and serving the purpose of supplying water to low pressure pumps for the settling basins of the water plant as well as for condensing purposes on the turbo generating units. Adjacent to this intake well is the low pressure pumping station having a total installed pumping capacity in motor-driven centrifugal units of some 90,000,000 gal. per day. Both of these investments are jointly used by the water and electric plant and, except for the installed capacity of pumping equipment, would amount to substantially the same total investment were either plant to be operated separately; hence a substantial saving in fixed charges to both plants is affected through this combination.

From this low pressure pumping station located on the river to the settling basins there are constructed two discharge mains that pass first through the turbo generating room and thence to the settling basins and they are so placed and inter-connected that either main can be used on any one of five turbo-generating units with the final discharge of water being made in the settling basins or wasted back to the river as load conditions may require. This flexibility of piping arrangement would, of course, be unnecessary were water delivered from the low service pumping station to the settling basins for water department use only, but inasmuch as the investment necessary for this flexibility is provided by the electric plant and the major portion would have to be provided whether operated in conjunction with the water plant or otherwise, this piping arrangement does not in any way affect the ultimate investment of the water plant. Of course some additional head is encountered because of increased friction in pumping water from the river through the more circuituous route required to serve the electric plant, and a further additional head of approximately 10 ft. is encountered through the normal friction of the surface condensers, but this difference in pumping head is absorbed by the electric plant in the proration of pumping costs between the two departments and hence does not effect any increase to the water plant.

Requirements for Condensing Purposes.—The advantages of this arrangement are limited to the balance of requirement for water in the settling basins of the water plant as compared with the requirement of water for condensing purposes in the electric plant; i. e., up to a point where the water required by the electric plant for condenser purposes does not exceed the amount required by the water plant for its particular function, the maximum of economy through this arrangement is obtained. After this point is reached, however, and the requirement for condensing water in the electric plant exceed the requirements of the water plant for water, the advantages, of course, commence to disappear and would eventually be lost altogether when the difference in water requirements of the two plants becomes great enough, because it is obvious that it would be expensive to pump excessive quantities of water at the higher head occuring through combined operation. However, when this point is reached, it is possible to still retain the major portion of these economies by interconnecting certain of the turbo-generating units in such a manner that only such capacities will be served in combined operation as will be justified by the water requirements of the water plant, the balance to be served through lower heads in connection with tailing pipes for river return.

In the design of condenser equipment at the Kansas City, Kan., electric plant we are required to specify a maximum water temperature existing in the Missouri River during the summer period of 80° F. and this, together with the relatively low steam pressure and superheat of the station and their resultant effect on the steam consumption of turbo-generating units, makes it necessary to specify approximately 2 sq. ft. of condenser surface for each kilowatt of turbo-generator rating, and with this temperature of circulating water it is necessary to have approximately 0.9 gal. per minute per square foot of condenser surface, or 1.8 gal. per minute per kilowatt of turbo-generator capacity.

At the present time our normal peak load is 19,000 kw. requiring circulating water at the rate of 34,000 gal. per minute. The load factor, however, on the electric plant is such that the average requirement for condenser water represents only 58 per cent of this amount, or approximately 19,000 gal. per minute, which is slightly in excess of the present average requirement of the water plant. This means that during times of peak load on the electric plant we are now forced to waste a certain per cent of circulating water back to the river which, of course, is the portion not required by the water plant, and this waste is of water which has been pumped at a head much higher than would be required for the electric plant only; hence this advantage of combined operation is commencing to decline in our plant because of the more rapid growth of the electric plant than that of the water plant. In order to maintain the greatest degree of economy in this feature through combined operation, it is proposed in the near future to isolate certain turbo-generating units and to provide separate pressure heads on the low service water pumping system.

I do not mean to leave the impression from the foregoing that this condition of operation has reached a point of wastefulness as yet, because the figures previously set out cover circulating water requirements under con-

ditions of high river water temperature and since, of course, the peak loads on the electric plant and water plant are not coincident, the waste of water during periods of peak load in the electric plant occurring during the fall and winter months, is not so very great because of the lower temperature of the river water during this period. In the warm period of the year the load on the electric plant is relatively lower and the volume of water required by the water plant is considerably greater, which permits the average result to still be entirely satisfactory.

The passing of this low pressure water through surface condensers gives an advantage to a water plant using open settling basins during the winter season of the year, due to the fact that the temperature of the water is increased enough to prevent the formation of ice on the settling basins, and this increase in temperature aids materially in the reaction of applied chemicals used for settling and treating purposes, but of course during the warmer periods of the year it appears as a disadvantage due to raising the temperature of the distributed water to a point higher than that of the river water, the ordinary rise over the condensers being between 10° and 15° F.

Electrically-Driven Pumping Equipment.—Combined operation of water and electric plants permits the economical use of a considerable amount of electrically-driven pumping equipment that would not prevail in a separately operated water plant. In Kansas City, Kan., the high pressure pumping equipment consists of two 12,500,000-gal. cross-compound, condensing, crank and flywheel type pumping engines and one 25,000,000-gal. two-stage synchronous motor-driven centrifugal pumping unit, and in the pumping of high pressure water by these units we again have the advantage of joint investment. This particular division of the water plant proper is operated on a customer basis with the electric plant; i. e., the electric plant furnishes to the water plant either steam for the operation of the high pressure steam pumping equipment or electric energy for the operation of the motor-driven high pressure equipment. Certain investments held jointly by the two departments are taken into consideration when fixing the rates charged for either steam or electricity to the water plant. The boiler plant building, for instance, houses equipment owned jointly by the two plants, by far the larger portion of which belongs to the electric plant, and this of course is served by a common set of coal and ash handling equipment and other auxiliary apparatus. Likewise, the main engine room houses high pressure pumping equipment as well as turbo-generating equipment and is served jointly by the same crane and other common facilities, and it is of course evident that if either plant were operated separately they would be required to support individually, though in a smaller way of course, these points of common investment, which would naturally reflect some increase in their fixed operating expense.

In the Kansas City, Kan., plant the 25,000,000-gal. motor-driven unit is operated as much of the time as possible. The reason for operating this unit continuously of course would not be parallel to what may be found in other pumping stations, but to us it means a substantial saving in operating expenses through the saving of packing, pump valves, lubricating oils and other miscellaneous materials used in the operation of crank and flywheel type of pumping units. Of course the present development in steam turbine-driven centrifugal pumping units would not offer by any means the same comparisons of economy as prevail in the Kansas City, Kan., station, but on the other hand where the size of the prime movers in the electric plant are sufficiently large to permit design having low steam consumption per kilowatt-hour, the ultimate duty obtained from a motor-driven unit is substantially the same as can be obtained from a steam turbine-driven unit of the same size and under the same conditions. The motor used on this centrifugal pump has been especially designed for power factor correction, and it is this feature in its continuous operation with the electric plant that enables the furnishing of electric energy to the water plant at a low rate because the electric plant benefits very materially through the operation of this motor in power factor correction on the station bus bars.

It is possible to operate in this manner without violating any requirements or suffering any penalties from the National Board of Fire Underwriters because the boiler plant is always under pressure serving the steam requirements of the electric plant and should electrical outage occur, the steam pumping equipment is ready to move on a moment's notice from steam supplied through the same source; hence continuous operation of the electrically-driven water pumping equipment is not burdened with any standby boiler expense, the only cost to the water department when operating with steam being that which they are charged on a per 1,000 lb. basis. The electric plant profits materially through this continuous operation of electrically-driven water pumping equipment to the extent that excitation losses on the turbo-generating units are reduced to a minimum and machine capacity is maintained at a maximum with of course decidedly improved regulation.

Effect on Personnel.—Another point of advantage in the combined operation of water and electric plants of course would apply generally to all combined installations, and that is the matter of superintendence, operation and maintenance of the equipment of both plants. For instance, in Kansas City, Kan., there is but one chief engineer of the power station who has complete supervision over both the water and electric plants and there is also one operating engineer on each shift who in turn supervises the operation of both plants during his time on duty. In the remaining members of the routine operating crews many instances occur where employees such as firemen, helpers, coal men, oilers, etc., divide their time between both plants, thus aiding materially in the reduction of operating costs.

In the matter of maintenance, the advantage of joint operation is again reflected in the fact that the same mechanics repair and maintain equipment of both plants, and while it is true that the combined operation requires possibly a somewhat larger number of men, it is also true that were the plants to be separated it would not be possible to diminish the crews by one-half, and it is Kansas City, Kan., experience that joint maintenance reflects very substantial savings to both plants in this respect.

Joint operation also permits the retention of a better class of technical employees such as engineers, draftsmen, etc., without excessive expense to either plant, thereby increasing operating efficiency of both plants and facilitating the careful planning of any needed additions or betterments to either plant as well as insuring the preparation and keeping of accurate maps and many statistical records concerning the extension and operations of both plants.

Owing to the wide diversity in the character of the work performed in the distribution of water and electricity throughout the city, it is not possible to effect any great economies through combined operation, although there are of course some few points of common interest involving the use particularly of unskilled labor that permits these departments to function somewhat more efficiently than were they controlled and operated by separate maintenance organizations. There is considerable advantage in the operation and maintenance of a common warehouse and store yard at which point materials are received and disbursed for the use of either the water plant or the electric plant. The store yard is supervised and operated by a single crew and were the two plants to be separated it is doubtful if over one-third of the help could be dispensed with, because so much of the work involved is routine and the excess is only measurable in the increased quantities of material to be handled through joint operation.

Effect on Major Administration Features.—A material saving is effected through joint operation of water and

electric plants in the major administration features as well as the billing and accounting departments. For instance, in Kansas City, Kan., there is one manager of production and distribution who is responsible for the production and distribution of both the water and electric plants. There is also one manager of collection and accounts responsible for the collection and accounting features of both plants; and while the state law very properly provides that separate sets of books and accounts must be maintained for both the water and electric departments, this does not mean that it is necessary to have a duplication of accountants, hence in Kansas City, Kan., one auditor supervises both sets of books, one cashier the collections of both departments, and one chief clerk the supervision of the billing of both departments, and were the plants to be separated it is obvious that practically all of these positions would be filled for each plant separately.

In the matter of reading of meters there is further economy due to the fact that a great percentage of our customers have both water and electric service and the meter readers are required to read both water and light meters; and while of course it may take somewhat longer to read two meters on the premises of one customer, it certainly doesn't take twice as long, consequently a substantial saving is made in this respect. These same general comments follow through the service and trouble departments where further duplication of employees is avoided through combined operation.

Water and Electric Rates and Costs.—Water rates in Kansas City, Kan., range from 25 ct. per 100 cu. ft., with a $1 minimum for the small user, to as low as 6 ct. per 100 cu. ft. for consumers using more than 400,000 cu. ft. of water per month, and considering the fact that these rates cover the treatment, filtration and distribution of the very difficult water encountered in the Missouri River, they are, all things considered, extremely low.

In the electric plant the average paid by all domestic customers during the past year was 3.8 ct. per kilowatt-hour, the average rate paid by all commercial customers was 3.7 ct. per kilowatt-hour, and the average rate paid by industrial power users was slightly over 1 ct. per kilowatt-hour, although several of these larger users have earned rates for the year substantially under 1 ct. per kilowatt-hour.

The average cost of pumping and distributing water for the year was 11 ct. per 1,000 gal., this figure including interest on outstanding bonds as well as depreciation at the rate of 2¾ per cent on the book value of the property. The cost of producing and distributing electric energy during the past year has averaged approximately 1.5 ct. per kilowatt-hour, although during the last six months it has fallen to as low as 1.3 ct. per kilowatt-hour; due principally to lower cost of fuel; and these production costs cover all items of expense, including interest on outstanding bonds as well as depreciation at an amount equal to 6 per cent of the book value of the entire property.

The purpose of the foregoing figures is to furnish some tangible evidence of economy resulting from the combined operation of the Kansas City, Kan., water and light plant and it has been conservatively estimated that were these two plants to be separated and operated under the prevailing conditions of load and equipment by separate operating organizations, the cost of producing and distributing electric energy would be increased by not less than 25 per cent, while the cost of pumping and distributing water would be increased by as much as 40 per cent.

It is not the writer's contention that these few remarks cover all the advantages to be gained through joint operation of water and electric plants, nor is it contended that all the points that have been mentioned are applicable to every plant, but generally speaking, it must be evident from the foregoing that many advantages of economical operation accrue through the joint operation of such utilities, and unless there are some extraordinary limiting physical conditions in a particular plant, these advantages greatly outweigh any disadvantages that may arise through such operation.

Acknowledgment.—The above is a paper presented Feb. 13 at the 8th annual Three Day School at the University of Kansas and the 5th annual meeting of the Kansas Water Works Association.

Rainfall in the 1927 New England Flood

When the New England Flood of November, 1927, occurred, says a statement from the Geological Survey, it resulted from the fact that a tropical storm moving up the Atlantic coast entered New England and was met by two high-pressure areas, one coming from the northeast and one from the northwest. The tropical storm was caught between the two cold areas of high pressure and was forced to pass over them, causing torrential rainfall. The ground had been thoroughly saturated by heavy rains during October, and natural storage capacity had been filled. Consequently the rivers quickly overflowed their banks, causing the most severe flood of which we have knowledge over extensive areas in New England.

A report just issued by the Department of the Interior as Water Supply Paper 636-C, by H. B. Kinnison, a hydraulic engineer of the Geological Survey, describes the unusual meteorologic conditions that caused the storm and presents extensive tables of rainfall for stations in the New England States, New York, and Canada. Maximum discharge and rates of discharge for 134 points on streams in the flooded area were determined. The highest recorded rainfall for the storm was at Somerset, Vt., where the total precipitation was 9.65 in. Considerably greater amounts of rain undoubtedly fell in the Green Mountains, which were not well covered by precipitation records. In general, the flood flows reached a maximum of more than 100 second-feet to the square mile of drainage area, and several determinations show 300 to 500 second-feet to the square mile. At many points the flood flow was reduced by storage in reservoirs which did not spill until the peak stages had occurred in the rivers below. An excellent example of the effect of reservoirs on flood flow is shown by the records for the Deerfield River, where storage in the Somerset and Davis Bridge Reservoirs reduced by 50 per cent the effective flood producing area of the river at Charlemont, Mass.

The total number of reported lives lost in New England was 85, one in Rhode Island and the rest in Vermont. The financial losses in Vermont were estimated at $28,000,000; the losses in highways, railroads, industries, and municipalities were about equal and each, roughly, 23 per cent of the total. The losses to railroads in New England because of the flood were almost $13,000,000, and the total loss as shown by incomplete estimates was more than $37,000,000.

Sewage Treatment Gaining in Ohio

During the last year marked progress was made in sewage treatment by cities in Ohio, according to "Ohio Health News" of Jan. 15. New modern plants were placed in operation at Alliance, Dayton, Elyria, New Lexington, Oxford and Salem. The Akron plant was placed in service during the last weeks of 1928. The seven foregoing plants are designed to serve a total population of 621,400. Toledo has awarded contracts for a plant and construction will be started shortly. Columbus is preparing plans for sewage treatment improvements.

There has been a marked improvement in operation of the smaller sewage treatment plants throughout the state. This is due to increased municipal funds for maintenance provided by sewer rental, supervision of operation of smaller plants by the superintendent of a neighboring larger plant, and the increased attention to this matter which is given by the State Department of Health. One assistant engineer spends a large portion of his time in visiting sewage treatment plants.

Decisions of the Ohio Supreme Court in the Bucyrus and Delphos cases have awakened other municipalities to the necessity of proper sewage disposal.

Aeration in Water Purification

Operating Results of Fine Spray Aeration at Several Filtration Plants

By MALCOLM PIRNIE
Consulting Engineer, New York, N. Y.

TILLMAN'S table* has made readily available the simple requirements for non-active waters. It is obvious from this table that to be non-active waters having bicarbonate alkalinities of less than 100 p.p.m. must not contain more than 2 p.p.m. of free CO_2 resulting in a pH between 8.1 and 8.3. Hence CO_2 is the chief offender in a clear filter effluent which is alkaline. Carbon dioxide is a dissolved gas found in clear waters from springs, wells, slow sand and rapid sand filters. It can be expelled by fine-spray aëration from clean waters down to a residual of from 2 to 4 p.p.m. The residual can be neutralized by adding hydrated lime at a rate of from 0.1 to 0.5 grains per gallon, resulting in a pH of 8 or over. Equivalent doses of caustic soda may be substituted for the lime whenever the addition of lime is undesirable. Such treatment may be provided at moderate cost compared with the resulting savings to all consumers of water.

Experiments on the effects of fine-spray aëration as a part of the purification process in treating various waters were begun by the author after the war. These experiments resulted in the adoption of fine-spray aëration both as a primary treatment and for expulsion of CO_2 from the filtered water at West Palm Beach, Fla., Albany, N. Y., and Providence, R. I. Fountain aëration of the settled water was installed at Watertown, N. Y. The waters treated by these plants are moderately to very soft and moderately to highly colored. Fine-spray aëration for the very turbid, soft Dan River water at Danville, Va., was provided for the water immediately after receiving the alum dose and has demonstrated its effectiveness during the last five years in producing satisfactory coagulation with much less alum and soda than was formerly required. Recent tests for a paper-mill supply from the acid waters of the upper Potomac River have shown that immediate fine-spray aëration after dosing with soda ash procedures an excellent quick-setting floc and a pH in the water equal to that produced by twice as much soda which, without aëration, yields a poor and finely-divided floc. In view of these tests and the fact that flood stages in the river carry turbidity similar to that in the Dan River, a fine-spray aërator is being designed for the dosed water before it enters the coagulation basins. The filter effluent will not be aërated, but the residual CO_2 will be completely neutralized with caustic soda.

*"Significance of Hydrogen-Ion Concentration in Drinking Water and Particularly for the Business of Water Supply," by A. Massink and J. A. Heymann, translated into English by Frank Hannan. Jour. A. W. W. A., vol. viii, p. 240.

In the filter plants just mentioned, aëration has proved to be invaluable as an aid to coagulation, as a means of reducing the corrosiveness of the water and in eliminating or greatly reducing tastes and odors. Operating results of some of the filters are given below. The results, with exception of the pH, are expressed in parts per million.

Providence, R. I.	Color	Total Hardness	Alkalinity	CO_2	pH
Raw Water	35	5	4.2	1.7	6.0
Effluent from First Aerator	....	6	....	1.6	6.1
Alum-Treated Water	....	....	....	5.3	5.9
Settled Water	....	....	....	3.8	6.1
Filtered Water	7	....	1.2	3.6	6.1
Effluent from Second Aerator	....	....	....	2.7	6.4
Effluent After Liming	11	10	4.5	0.2	7.7

West Palm Beach, Fla.—Average results of operation during February, 1929.—Raw water is dosed with an average of 3.32 grains per gallon of alum; pumped to aërator; falls into coagulation basins; passes through filters; effluent controlled by aëration in fine-spray nozzles and variable nozzle; water from effluent aërator treated with 0.14 grain per gallon of lime (Table I).

Table I	Color	Alkalinity	CO_2	pH
Raw Water	107	25	1.5	7.3
Alum-Treated Water	....	.....	28.0*	5.5*
Water on Top of Filters	24	3.7	5.5	6.3
Aerator Effluent	15	6.0	3.3	6.7
Water in Clear Well After Liming	14	7.4	2.4	6.9

*Result of one test; not part of routine tests.

Harder well water is used for washing filters and causes increase in alkalinity in the effluent aërator. About three times as much lime should have been added to produce pH near 8.

Providence, R. I.—Average results of operation during January, 1929.—Raw water is aërated; dosed with 0.54 grain per gallon of alum; passes through a mixer into open basins holding it about six days. Settled water passes through filters; filter effluent controlled by aëration similar to West Palm Beach; water from effluent aërator treated with 0.18 grain per gallon of lime.

In April, May and June, 1929, a pH average of 8.0 to 8.1 was obtained with 0.15 to 0.17 grain per gallon of lime.

Watertown, N. Y.—Test of operation, November 6, 1922.—Raw water dosed with 3.3 grains per gallon of alum as it enters an 8-day river basin through a mixer. Settled water aërated in a fountain and filtered.

Watertown, N. Y.	Paper Filtered Color	Alkalinity	CO_2	pH
Raw Water	90	32	3	6.9
Alum-Treated Water	17	13	23	5.9
Water halfway through River Basin	6	11	7	6.4
Outlet from River Basin	5	11	6	6.5
Filter Effluent	3	12	2	6.8

This water needed about 0.15 grain per gallon of lime to raise its pH close to 8.

Danville, Va.—Experiment, February 12, 1923.—Raw water dosed with 0.8 grain per gallon of soda ash followed by 2.0 grains per gallon of alum. Dosed water was mixed thoroughly and half of it immediately aërated. Both portions were then allowed to stand a few minutes.

Danville, Va.	Turbidity	Alkalinity	CO_2	pH
Raw Water	180	16.5	2	7.4
Treated Water Not Aerated	No Floc	13.5	7	6.6
Treated Water Aerated	Excellent Floc	14.0	2	7.2
Water Filtered Through Cotton	0	14.0	2	7.2

Test of Plant Operation Aug. 28, 1929.—Raw water first dosed with 1.25 grains per gallon of alum and aërated through fine-spray aërator. Effluent from the aërator filtered and tested.

Danville, Va.	Turbidity	Alkalinity	CO_2	pH
Raw Water	500	22	....	7.1
Treated Water Aerated and Filtered	0	10	4.5	6.5

Caustic soda is to be applied to the effluent to produce a pH close to 8. Less than a grain per gallon will usually be required.

Acknowledgement. — The foregoing was presented at the 1929 convention of the New England Water Works Association.

Zeolite Water Softening for Municipal Purposes

General Features of Zeolite Softening Plant, of Combination Treatment Lime Followed by Zeolite, Together with Descriptions of Two Recently Installed Municipal Zeolite Softening Plants

By H. B. CRANE

Principal Assistant Engineer, International Filter Co., Chicago

THE illustration, Fig. 1, is a flow diagram through a pressure type zeolite softening plant. The equipment shown is suitable for handling a clean, clear raw water supply that does not need filtering. In operating, raw water is pumped through the softener directly into the distributing system, and when the capacity of the zeolite has been utilized, the raw water pump is stopped and a solution of common salt brine is applied to restore the softening properties of the zeolite. A standard soap test, made upon the softened water, is the only one that the operator has to make.

The maximum flow rate per unit that can be obtained from equipment like this is in the neighborhood of 600 G.P.M., and that quantity only under what may be termed favorable operating conditions. This limitation as to flow rate exists because of mechanical difficulties encountered in the construction of pressure steel tanks, and the fact that insufficient time for contact between hard water and zeolite is given, if the velocity of flow through the bed is excessive.

As to the construction of steel pressure tanks,—the diameters of these are limited to 10 or 11 feet in all cases where they are to be shipped assembled, because railroad clearances are generally such that larger tanks than these cannot be handled. The cross sectional area of a 10-foot diameter tank is 78.5 sq. ft., and if the total hardness and composition of the hard water is such that a 7-gal. per square foot per minute operating rate is permissible, it would appear that a single unit softener of this type might satisfactorily handle the requirements of a city of 4,000 or 5,000 inhabitants. This is actually not the case, however, because such a wide variation generally exists in any city of this size, between maximum and minimum softened water demands that it would not be economical to operate by direct pumpage. A clear well below the softener would be provided and a high service pump installed to afford greater protection in meeting variable demands and to insure greater operating economy.

It is impossible to supply any figures that may be applied generally in arriving at the probable cost of a zeolite plant. Too many variables must be considered to make this possible. For example, the capacity between regenerations, the permissible operating rate, and salt consumption of the zeolite are based upon the hardness and chemical composition of the water to be treated. Capacity and operating rate are higher for waters of low hardness than they are for waters of high hardness, while salt consumption may vary with the amount of raw water hardness present. A reliable cost estimate for a zeolite plant cannot be made until all the variable conditions that may affect its size and operation are known.

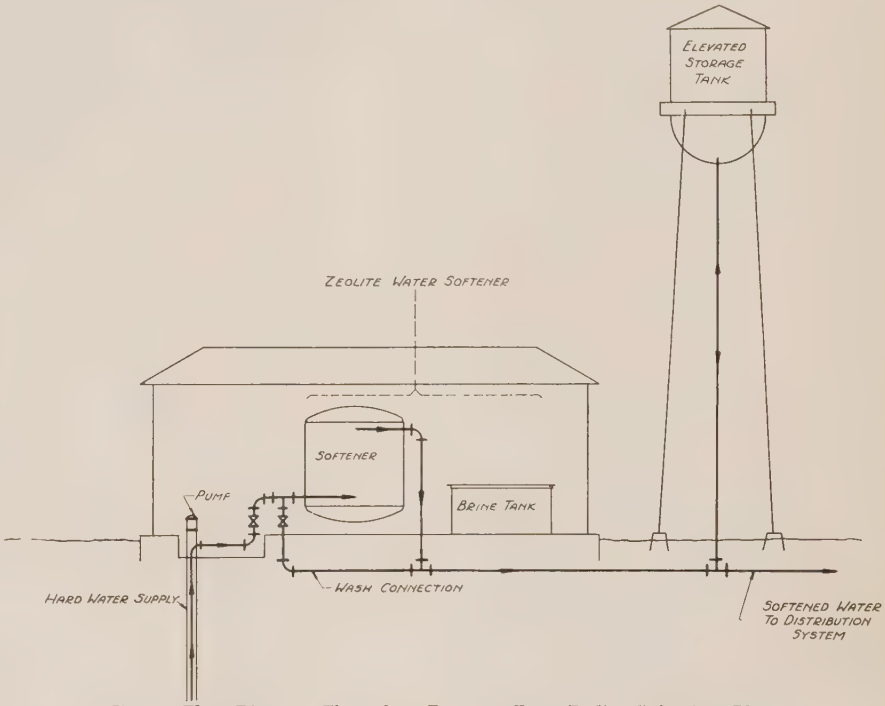

Fig. 1—Flow Diagram Through a Pressure Type Zeolite Softening Plant

Lime-Zeolite Softening Plant.—Figure 2 is a flow diagram of a lime-zeolite softening plant in which pressure shells are used as containers for filter sand and zeolite and in which a steel or wood tank may be used for coagulation and sedimentation. Here, the raw water is pumped to the top of the coagulating tank, where sufficient lime is added to remove practically all of the carbonate hardness. After settling, sufficient CO_2 gas is added to stabilize the water and prevent after-precipitation on sand or zeolite beds and in pipe lines. The high service pump then forces the water through the sand filter to clarify it and also through the zeolite bed where all remaining hardness is removed, and thence into the distribution system.

The illustrations thus far have all indicated types of plant construction that are suitable primarily for the smaller cities and towns. Different construction materials than those indicated are more economical for plants softening a million gallons or more daily, and in these cases, reinforced concrete supplants wood or steel in tank and reservoir construction. Gravity filter and zeolite beds are used because large volumes of sand and zeolite can be most economically handled that way, while coagulating basins are built practically at ground level to save money in construction and operation.

Steps in Treatment in Lime-Zeolite Plant.—Figure 3 is also a flow diagram which shows how the various steps in treatment are carried out in a lime-zeolite softening plant of sufficient size to warrant reinforced concrete construction throughout. From the source of supply, the hard water is pumped to the reaction tanks where sufficient lime is added to remove all the carbonate hardness. It flows from these tanks under the head established there, through the coagulating basins, the filters and into the clear well for lime softened water underneath the filters, being stabilized with CO_2 gas enroute at the point indicated. The first clear well must be large enough to hold sufficient water for operating whatever number of zeolite beds are required, together

with sufficient quantities for backwashing filters, washing and brining zeolite beds plus a reasonable margin to supply demands when one or more filters may be out of service for repairs.

Transfer pumps pick up the lime treated water and force it through the zeolite beds and thence to the second compartment of the clear well which stores the zeolite softened water. The high service pumps of course supply the distribution system. Low head pumps handle the transfer service mentioned above,—not over 25 or 30 ft. head (including suction lift) has to be overcome in the transfer from one clear well to the other, during which the zeolite softening takes place.

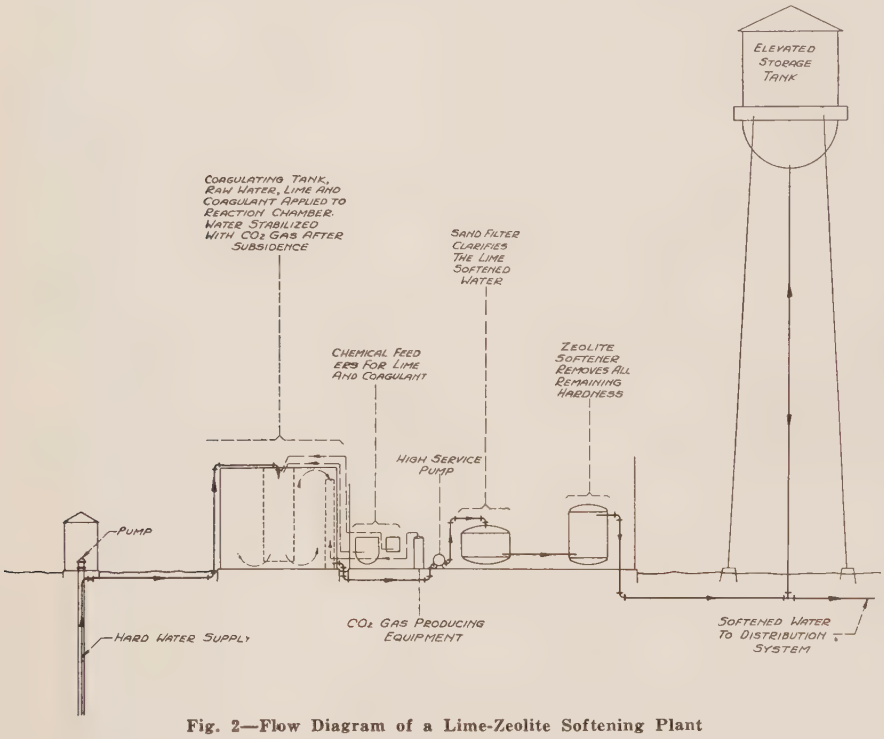

Fig. 2—Flow Diagram of a Lime-Zeolite Softening Plant

Control of Hardness.—Quite a few municipal water softening plants are so operated that the hardness of the finished product is controlled. This is accomplished by mixing in correct proportions, water that has been completely softened with hard water or water that has had only part of its original hardness removed. For example, lime or lime and soda softened water may be mixed with the unsoftened supply; zeolite softened (zero) water with hard; or lime softened water with zeolite softened water in the case of the combined treatment described above. A water of uniform hardness can easily enough be maintained, and no more change in chemical quality occurs than in total hardness. It seems unnecessary, and in some cases it may be even inadvisable to completely soften the city's water supply that is used for all purposes, and an appreciable saving can be made in raising the hardness of the product to 6 or 7 grains. The mixing of waters of different hardness can take place in the clear well and be automatically controlled by proportioning the quantities of softened and hardening waters entering the well.

Brief descriptions will be given of two municipal zeolite softening plants recently installed. These plants are representative of modern practices in construction and operation, and the general features of both are applicable to softening many Kansas supplies.

Zeolite Softening Plant of Springdale, Pa.—Figure 4 is an illustration of the softeners operated by the Borough of Springdale, Pa. The water supply comes from several wells, the average hardness of which is about 20 grains per gallon, the ratio of temporary to permanent hardness content being almost 2 to 1. It is pumped upwardly through the zeolite beds, the softened water is collected at the top and flows from that point to a softened water storage reservoir of considerable size located below the softeners. The zeolite beds are approximately 78 in. in depth and the two steel tanks shown, open at the top, are 7 ft. in diameter and 12 ft. high.

Each softener produces 90,000 gal. of zero hardness water per regeneration and the operating rate for each is approximately 230 G.P.M.

The salt consumption under these conditions averages about .325 pounds per 1,000 grains of hardness removed. Salt is purchased in bulk, car lots, and is stored in a wet salt bin or saturator built of reinforced concrete outside the softener building. The saturated solution flows by gravity to a small dosing tank inside the building and is applied to the zeolite during regeneration by an hydraulic ejector which pumps the strong brine out of the dosing tank, dilutes it with the pressure water used and forces the diluted brine through the zeolite bed.

High service pumps, brine dosing tank and a high service venturi meter are all located in a pit in front of the softeners. The building extends over the entire water softening plant and softened water reservoir, is substantially built of brick and presents a very attractive appearance.

Water of no hardness is pumped into the mains at Springdale.

Zeolite Plant Softening Plant of Mangum, Okla.—A zeolite plant of quite different construction and arrangement is operated by the city of Mangum, Okla. The water treated there also comes from wells and averages about 28 grains per gallon total hardness, the quantity of carbonate hardness present being in excess of the non-carbonate.

The plant is designed to supply the city with 1 M.G.D. of water containing 3 grains per gallon of hardness, the hardness being automatically controlled here by bypassing and mixing a portion of hard water with the completely softened water from the zeolite beds.

The zeolite beds, 66 in. deep, are operated in two reinforced concrete gravity basins 11x12 ft. in plan and 10 ft. deep. Fig. 5 is an interior view of the softening plant showing the operating control tables with the two zeolite beds in the background. A salt saturator

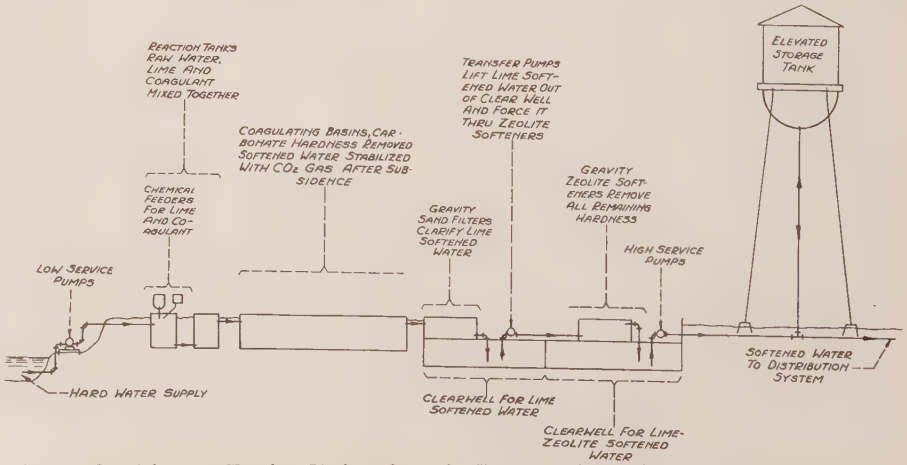

Fig. 3—Flow Diagram Showing Various Steps in Treatment in a Lime-Zeolite Softening Plant

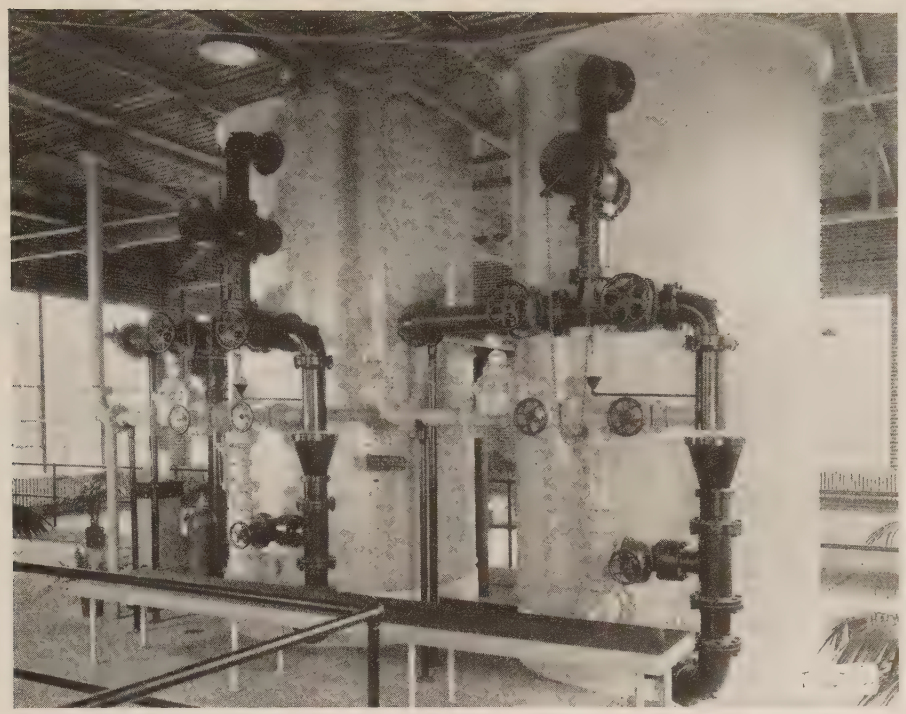

Fig. 4—Softeners Operated by Borough of Springdale, Pa.

and brine measuring sump are located in the building at the left of the picture. Diluted brine is forced through the beds during regeneration by two brine pumps located in the pipe gallery. The average amount of salt used at Mangum is 0.375 lb. per 1,000 grains of hardness removed, a very low salt consumption considering the hardness of the raw water.

This plant is designed and operated much the same as a concrete gravity filter plant. All equipment necessary to secure flexibility and economical operation has been provided.

There is much to be said in favor of softening municipal water supplies with zeolite and if raw water supply conditions are such that this treatment is applicable, its possibilities should be thoroughly investigated. Salt now-a-days is cheap, the softening plant is economical in space requirements, the mechanical equipment is easily taken care of, and operation can be largely a matter of routine.

Acknowledgment.—The foregoing is an abstract of a paper presented Feb. 12 at the fifth annual meeting of the Kansas Waterworks Association.

Starch Coating for Painted Concrete

If a coating of starch is applied to a painted concrete surface, the surface may be cleaned by washing away the coating. Following the washing a fresh coat may be applied.

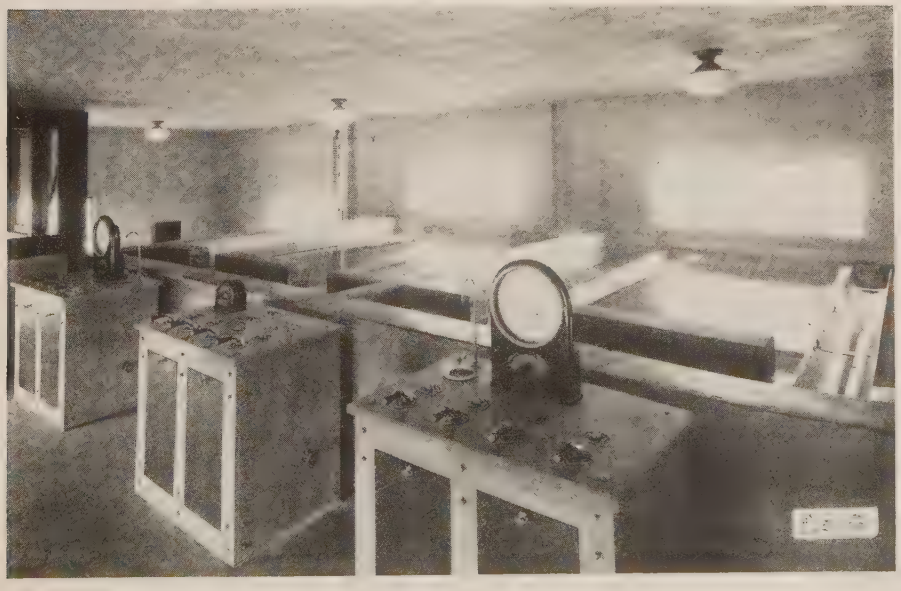

Fig. 5—Interior View of Zeolite Plant at Mangum, Okla., Showing Operating Control Tables with Two Zeolite Beds in Background

Hackensack Water Co. Will Have Central Service Yard

Development of the new Hackensack yard of the Hackensack Water Company, located near the Fairmount Avenue station of the New Jersey & New York Railroad in North Hackensack, N. J. is proceeding rapidly, and by Spring the yard will begin to function as the distribution and service center of the towns supplied by the company.

A railroad siding about 800 ft. long has been installed, and a travelling gantry crane with an overall span of 120 feet has been erected in order speedily and economically to unload and handle pipe and other heavy materials. Pipe will be stored there this winter.

Grading, which involves the excavation and removal of 9,500 cu. yd. of earth, is under way, following the installation of a drainage system. The lower level of the site will be raised from one to three feet, and the upper grade fronting on Hackensack Street will be lowered and straightened by a concrete retaining wall. Building operations will commence as soon as practicable.

The property is 1,000 ft. long and 200 ft. wide with an entrance on Temple Avenue and on Hackensack Avenue. Fronting the lower court will be a large warehouse one story high, and an office building to house the construction division staff.

On the upper level is the rear of the office structure and fronting on a central court will be a motor vehicle repair shop, facilities for employees, and garages for both large and small trucks. The plans provide for extensions to the garages and for a meter repair and testing shop.

The purpose of the yard, according to the President of the Company, Nicholas S. Hill, Jr., is the consolidation of supplies and materials and of transportation and construction control. Operating in connection with the Central Service Bureau of the Company at Weehawken, the new division yard will enable the water supply organization to respond more readily to the needs of the communities served.

The company now maintains pipe yards at Englewood, Hackensack, Carlstadt, New Milford, and Westwood. These are being merged into one mechanically served yard, eliminating the hand loading of pipe at scattered railroad stations.

1930 Convention of Southeastern Section, A. W. W. A.—The 19th annual convention of the Southeastern Section of the American Water Works Association will be held in Savannah, Ga., April 15, 16, and 17. W. H. Chapman, Laurens, S. C., is secretary-treasurer.

Water Works and Sewerage

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Announcing "Motive Power," the Sixth Magazine of the Gillette Group

Twenty-four years ago last month the first of the Gillette Group of magazines was launched, namely "Engineering and Contracting." A sixth member, "Motive Power," now joins this group. In the order of seniority the group consists of:

Engineering and Contracting.
Roads and Streets.
Water Works and Sewerage.
Tiles and Tile Work.
Motor Freight.
Motive Power.

Each of the six is a highly specialized magazine, and, with one exception, each is the circulation leader in its specialized field.

"Motive Power" does not attempt to cover the broad field of prime movers, but only that part of the field in which the power units are portable. Perhaps with equal propriety its name might be Mobile Power. There is no other power magazine in this highly specialized field, but it seemed clear to the publisher that the time is ripe for the introduction of such a magazine.

The problems of the designers and users of large stationary power units have only a general kinship with the problems that exist where small, portable power units are required. To make this strikingly evident take the problem of fuel efficiency in a turbogenerator plant of 50,000 kilowatts running continuously, and contrast it with the fuel problem in a 5 horse-power gasoline motor used intermittently to operate a construction derrick. In the first case the fuel consumption per kilowatt-hour is of paramount importance. In the second case it is of negligible importance. But in the case of the small portable power unit, there looms into prominence its ruggedness and ability to stand up under rough handling and when exposed to every sort of weather. Like the modern motor on an automobile it must be "fool proof," in addition to which it must be "weather proof" and capable of working in a cloud of dust that would stifle a less rugged machine.

In a sense the portable power units that operate construction machinery are mechanical mules, and like their muscular prototypes they must be able to work in dust, rain and mud, without balking on their rough drivers. An experienced contractor knows this fact, and always has known it, and that is why it was many years before such a contractor could be induced to use a gasoline engine; for in the early stages of the development of that type of motive power units, they were as unreliable as a Hottentot's promise. The designers of those early gasoline engines were trained mechanical engineers, but their training had been in the designing of large, stationary power units, that were operated by skilled mechanics, and they had yet to learn that there is a great deal of difference between such conditions and those under which a mechanical mule must labor.

The editor recalls that a large public utility company once employed one of the most celebrated consulting power plant engineers to investigate and report on the make of automobile best adapted to their needs. The report was received and several scores of motor cars were purchased according to the recommendation of that engineer. But it soon developed that that make of car was very unsatisfactory. One of the officers of the utility company told the editor that almost the poorest car for their uses was the one that had been recommended by that celebrated power plant engineer. The reason was that although he knew a great deal about large, stationary power units, his knowledge about small, portable units that would be subjected to shocks and rough, careless usage, was really nil. In brief, there are important differences in correctly designing stationary power units and portable power units.

The designer of any machine should be very familiar with the conditions under which it is to be operated. And of course this is equally true of the buyer of the machine. The buyer often knows much more about these conditions than does the designer, so it is very important that the two shall meet to discuss their mutual problems. "Motive Power" expects to furnish a common meeting place for the exchange of facts and ideas. Here also will come the "dealer" in portable equipment operated by power, for he is not only a "middleman" in the sense that he buys to sell again, but in the sense that he conveys information from manufacturer to ultimate buyer and vice versa. He performs an important economic service in exercising both these functions. Also he should be so well informed as to the suitability of each device for any particular kind of service that he can give the best of advice to the ultimate buyer. Finally he should be able to instruct the user of the device as to its most effective handling and maintenance. Let no one think that this sort of "middleman" is an economic burden whose profits should be eliminated by eliminating his services. Quite the contrary. He performs services that can not be dispensed with without economic loss, and since the best of all ways of compensating men is to pay them in proportion to their performance, the profits made by such "middlemen" are not to be begrudged, but rather to be regarded as income earned by satisfactory service.

"Motive Power" will naturally have as its readers the designers and manufacturers of mobile power units, the manufacturers who equip their machines with such units and the dealers who sell those machines to the ultimate users. No special attempt will be made to reach many of the ultimate users with "Motive Power," although the most progressive of them will doubtless

subscribe for this magazine. Other power magazines go mainly to ultimate users of power machinery. They perform an excellent service in showing the power plant superintendent and the "engineman" how to operate machinery with economy. "Motive Power" will not duplicate that service to the ultimate user of power units, but will confine its efforts to aiding the designer and manufacturer of power units and accessory equipment, also the manufacturer who "powers" his portable machines, and the equipment dealer who distributes them to the ultimate user.

Presidents, chief engineers, purchasing agents and other officials of manufacturing companies that use powered equipment and their dealers or distributors will comprise the major part of the subscription list of "Motive Power." To give an idea of the extent of this field of mobile powered equipment the following partial list will serve:

Construction machinery:
- Concrete mixers
- Road rollers
- Road graders
- Excavators
- Derricks and hoists
- Tractors
- Trench pumps
- Air compressors
- Conveyors

Agricultural machinery
Mining machinery
Manufacturing machinery
Logging machinery
Oil field machinery
Earth borers and drillers
Portable saw rigs
Lawn and golf course equipment
Portable electric generators
Welding equipment
Spraying equipment
Fire apparatus
Pumps
Washing machines
Material handling machinery
Motor trucks

The first issue of "Motive Power" furnishes a rather extensive review of the newest developments in mobile power units and the uses to which they are put.

Who Was Semmelweiss?

When the editor was a college student he was taught that no material particles flow through a conductor where an electric current flows, and that it was merely a convenient "scientific fiction" to picture an electric current as a flow of particles. We were told that a wire carrying a strong current is no heavier than when it carries no current; and this was regarded as conclusive proof of the non-materiality of the electric current. Shortly after that time, however, the great English physicist, J. J. Thomson, discovered the electron and determined approximately its mass. Later it was shown that when electrons flow through a conductor they cause electric currents and the concomitant magnetic effects. So, after generations of teaching that Benjamin Franklin was wrong in believing electricity to be a current of material particles, we have come back to belief in Franklin's theory.

Similarly we were taught that heat is not a substance, because hot bodies seemed to be no heavier than cold bodies. The old "phlogiston" theory of heat as a substance was ridiculed by our teachers. Now we know that all energy has mass and gravitates, and that the sun literally sends tons of heat to the earth.

Yet in spite of the radical upset that many physical theories have experienced in recent years, not a little of the old cocksureness still dominates the minds of many scientists. Present to them any radically new theory, and you will become convinced that the typical scientist enjoys nothing quite so well as showing you how wrong you are, unless it be that he enjoys even more the assumption of an attitude of supreme indifference to new theories. It took Einstein almost a generation to secure general recognition of the truth of his relativity theory. It took Agassiz two generations to convince the majority of geologists that his ice-age theory is correct. Fourteen years after Lister had published his discoveries about the antiseptic treatment of wounds, three American surgeons (one an army surgeon) let the editor's brother almost die for lack of such treatment. More than a decade after the efficacy of chlorination of water as a destroyer of typhoid germs was completely proved, thousands of Americans were dying of typhoid every year because doctors either did not know, or, knowing, did not tell the public to chlorinate all city water. And to this day you dare not drink the water that flows from the taps in many a European city. Since the cost of water chlorination is only 2 ct. per capita per annum, the cost does not prevent its use. What does? Ignorance unadulterated and almost universal. Fully three-fourths of the people on this globe do not know how to protect themselves against typhoid. But we need not brag, for the same was true in enlightened America only a few years ago.

Speaking of Lister's great discovery that dilute carbolic acid treatment of wounds destroys septic bacteria, we are reminded of an even earlier discovery of similar nature that Lister had not heard of when he made his epochal discovery. We refer to a discovery made in 1847 by Semmelweiss, Hungarian physician and research genius. He found that by washing their hands with chlorinated lime water, physicians in the lying-in wards of his hospital were soon able to reduce the former mortality ratio of 12 per cent to 3 per cent and later to but slightly more than 1 per cent. Semmelweiss was just an assistant professor in the maternity department in Vienna, and had graduated only three years before he made this great discovery. His superior officer, one Dr. Klein, was so "blinded by jealousy and vanity" that he "drove Semmelweiss from Vienna in 1849." But in the following year Semmelweiss repeated his great achievement in another hospital, where he reduced the mortality well below 1 per cent. He taught other physicians his methods, and in 1861 he published a very full account of it. Lister's antiseptic experiments were not begun till 1864 and his first publication on the subject was in 1867, six years after Semmelweiss had published his first complete account of antiseptic treatment in puerperal cases. It matters little that Lister was a surgeon and Semmelweiss a physician. It does matter, however, that Lister had not heard of Semmelweiss, for that is an

excellent illustration of the ill results of scientific skepticism and professional jealousy. Semmelweiss later was a prophet, but without honor abroad and with scant honor at home. Lister was fortunately and deservedly raised to the British peerage by his discovery of antiseptic treatment, yet even his methods remained unused in many parts of America well into the 80's. Tell us why.

In Kleinn's attitude toward Semmelweiss we see, in extreme form, what probably occurs in mild form far oftener than is supposed, namely an attitude of jealous intolerance. Let any radically new theory be presented before a professional body, and note either the acrimony and sarcasm with which it is usually greeted, or the silence that so often speaks contempt. Note the eagerness and the evident delight with which some apparent defect in a new theory is pointed out. Noting such evidences, be disillusioned if your illusion has been that scientists are of an emotional structure that differs from that of other men.

Ignatz Phillipp Semmelweiss, research genius, died broken hearted and in poverty at the age of 47. Where was Fame dallying that month of May, 1847, when Semmelweiss demonstrated the effectiveness of antiseptic treatment? Holding converse with Jealousy?

"Scientific Caution" Often Born of Ignorance of the Science of Probability

When a new theory knocks at the portals of established science asking admittance, it is commonly met with this question: What authorities vouch for your truth? While this is a reasonable question on the part of a layman, it is wholly unreasonable on the part of scientists who specialize in the field to which the theory relates. They should ask not who is sponsor for the truth of the theory, but what facts indorse it. As a case in point we may quote from Prof. Goldthwait's preface to Antevs' "Recession of the Last Ice Sheet in New England." Speaking of Agassiz's ice-age theory he says: "American geologists for 20 or 30 years hesitated to accept the new explanation (of drift phenomena), owing to the difficulty of conceiving a glacier so thick and so extensive that it could spread its records continuously across uplands and valleys. The unhappy effect of an inhospitable attitude toward a new theory and new methods was clearly illustrated here during the period from 1841 to 1870, when the glacial theory was on probation. Lively discussions of it, as reported in contemporary proceedings of our scientific societies, betray the human tendency to judge a theory by the number and prestige of its adherents and converts instead of by careful and impartial consideration of the evidence."

There is in such cases—and they may be said to be typical—abundant evidence of a combination of professional jealousy and ignorance of research methods that is most discouraging. Since there is little hope of changing human nature save by slow evolution, we will not discuss the professional jealousy feature of the opposition to a new theory. As to removing ignorance of research methods, there is much more hope. In fact, it is certain that this can be accomplished.

To begin with, all scientific men should be taught to read the history of science enough to see for themselves that every theory was not only imperfect at its birth, but has remained imperfect to the present day. Once this fact is fully grasped, it becomes obvious that no theory should ever be rejected because of its defects, provided only that it is in accord with a sufficient body of facts to render its fundamental truth at least possible. Scientists not well enough read to have come to this conclusion are prone to seek for a defect in any new theory, and exultantly hold it aloft as proof conclusive that the theory is false. "False in one, false in all" may be a good maxim by which to judge the reliability of a witness, but it is the poorest of guides in judging the merit of a theory.

Most of us know that an invention is invariably so defective in the early stages of its development that it looks hopeless to all but the inventor himself. Much the same is true of a new scientific theory. Everyone but its discoverer is prone to regard it as fantastic. The discoverer alone sees in it possibilities of development.

Theories always develop. A theory starts as a rather crude explanation, suggested by some analogy between a well known phenomenon that the theory aims to explain. Gradually it becomes evident that while the two phenomena are somewhat alike, they differ enough to make it necessary to modify the embryonic theory. And so, step by step, the theory is modified to bring it into closer and closer accord with the facts. Perfect accord is never attained. Until Einstein appeared on the scene, there was at least one theory, namely, Newton's theory of gravitation, that was regarded as perfect. But behold the recent change of scientific belief!

Jevons was the first scientific writer, we believe, to voice the opinion that no scientific law is perfect. In his "Principles of Science," p. 450, he says: "The further we advance in any generalization, the more numerous and intricate are the exceptional cases still demanding further treatment. The experiments of Boyle, Mariotte, Dalton, Gay-Lussac, and others, upon the physical properties of gases might seem to have exhausted that subject by showing that all gases obey the same laws as regards temperature, pressure and volume. But in reality these laws are only approximately true, and the divergencies have afforded a wide and yet quite unexhausted field for further generalization." On an earlier page (146) he said: "Seldom, indeed, shall we have a theory free from difficulties and apparent inconsistency with facts. . . . Almost every problem in science thus takes the form of a balance of probabilities."

This last sentence gives us another clue to the reluctance of scientists to endorse a new theory. Very few of them seem to know how to weigh a probability. Yet without that sort of knowledge they are incapable of passing safe judgment upon any theory that is susceptible of test by a probability calculation. Undoubtedly "scientific caution" is usually born of a timidity that springs from lack of knowledge of that branch of science known as Probability.

H. P. Gillette

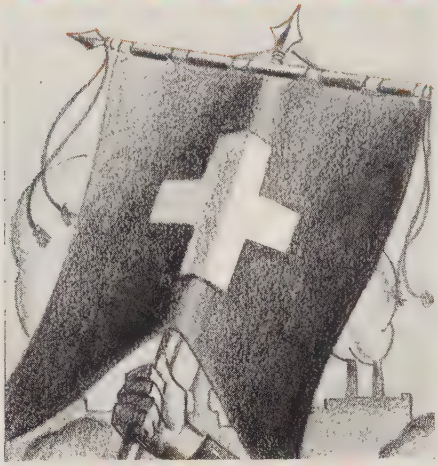
WATER & WORKS SEWERAGE

Design ~ Construction ~ Collection
Treatment ~ Distribution ~ Disposal

March, 1930 — W. P. Gillette Editor — Vol. LXXVII. No. 3

Head House of Filtration Plant of Providence, R. I.

HEALTHY CITIES *are* PROSPEROUS CITIES



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There is yet much to be learned about the treatment of sewage and industrial wastes. However, the standards of civic sanitation are steadily being advanced, as indicated by the increasing number of sewage treatment plants.

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Water Works and Sewerage

H. P. GILLETTE, Editor

Vol. LXIX MARCH, 1930 No. 3

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Aftercoolers, Air
Chicago Pneumatic Tool Co., New York City.
Ingersoll-Rand Co., New York City.
Sullivan Machy. Co., 819 Wrigley Bldg., Chicago, Ill.

Air Ducts, Steel
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Air Lifts
Chicago Pneumatic Tool Co., New York, N. Y.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Asbestos Lead Lined Runners
Coleman, Allan J., Chicago, Ill.

Asbestos Specialties
Philip Carey Co., Cincinnati, O.

Ash Handling Machinery
Haiss Mfg. Co., Geo., New York City.

Asphalt
Asphalt Association, New York City.
Barker Asphalt Co., The, Phil. Pa.
Barrett Co., New York City.
Finley, Inc., S. E., Atlanta, Ga.
Kentucky Rock Asphalt Co., Louisville, Ky.
Servicised Products Corp., Chicago, Ill.
Standard Oil Co., of Indiana, Chicago
Standard Oil Co. of N. Y., New York City.
The Texas Co., New York City.
West Process Pavement Co., Louisville, Ky.

Asphalt Pavement Repair Outfits
Aeroil Burner Co., Inc., West New York, N. J.
Hauck Mfg. Co., Brooklyn, N. Y.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Asphalts, Paving, Waterproofing
Servicised Premoulded Products, Inc., 53 W. Jackson Blvd., Chicago, Ill.

Asphalt Planking, Flooring, Waterproofing Sheets
Servicised Premoulded Products, Inc., 53 W. Jackson Blvd., Chicago, Ill.

Asphalt Plants, Portable
Aeroil Burner Co., Inc., West New York, N. J.
Etnyre & Co., E. D., Inc., 63 Jefferson St., Oregon, Ill.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
The Simplicity System Co., Chattanooga, Tenn.

Asphaltic Emulsions
Colphalt Co., Cleveland, O.

Augers, Pipe
Coleman, Allen, Chicago, Ill.

Axles
Electric Wheel Co., Quincy, Ill.

Back-Fillers
American Cement Machine Co., 251 E. Baker Manufacturing Co., The, 506 Stanford Ave., Springfield, Ill.
Buckeye Traction Ditcher Co., Findlay, Ohio.
Bucyrus-Erie, So. Milwaukee, Wis.
Chicago Pneumatic Tool Co., New York.
Galion Iron Works, Galion, O.
General Excavator Co., Marion, O.
Harnischfeger Corp., Milwaukee, Wis.
Keystone Driller Co., Beaver Falls, Pa.
Ohio Power Shovel Co., Lima, O.
Speeder Machinery Co., Cedar Rapids, Ia.

Backfiller-Cranes
Buckeye Traction Ditcher Co., Cleveland, O.

Back Slopers
Adams Co., J. D., Indianapolis, Ind.

Balancing Machines, Static-Dynamic
Tinius Olsen Testing Machine Co., 504 N. 12th St., Philadelphia, Pa.

Bar Benders & Cutters
Koehring Company, Milwaukee, Wis.
Ransome Concrete Machinery Co., Dunnellen, N. J.
Ryerson & Son, Jos. T., Chicago, Ill.

Bars, Iron & Steel
Carnegie Steel Co., Pittsburgh, Pa.
Ryerson & Son, Joseph T., Chicago.

Bars, Iron & Steel Reinforcing
American Steel & Wire Co., Chicago.
Carnegie Steel, Pittsburgh, Pa.
Ryerson & Son, Jos. T., Chicago, Ill.
Truscon Steel Co., Youngstown, O.

Batch Boxes
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
Western Wheeled Scraper Co., Aurora, Ill.

Batchers, Adjustable
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Butler Bin Co., Waukesha, Wis.
Heltzel Steel Form & Iron Co., Warren, O.
Johnson Company, C. S., Champaign, Ill.

Batcher Plants
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Beams
Carnegie Steel Co., Pittsburgh, Pa.
Ryerson & Son, Joseph T., Chicago.

Bearings
Hyatt Roller Bearing Co., Harrison, N. J.
Timken Roller Bearing Co., Canton, O.

Binders Paving
American Tar Products Corp., Pittsburgh, Pa.
Barrett Co., New York City.
Carey Co., Philip, Cincinnati, O.
Kentucky Rock Asphalt Co., Louisville.
Servicised Products Corp, Chicago.
Standard Oil Co. of Indiana, Chicago.
Standard Oil Co. of New York, New York City.
The Texas Co., New York City.

Bins, Storage
Butler Bin Co., Waukesha, Wis.
Johnson Company, C S., Champaign, Ill.
Pioneer Gravel Equipment Mfg. Co., Minneapolis, Minn.

Bituminous-Fibre Sheets for Decking
Servicised Premoulded Products, Inc., 53 W. Jackson Blvd., Chicago, Ill.

Bituminous Heaters & Sprayers
Etnyre & Co., E. D., Oregon, Ill.

Blades, Grader
Adams Co., J. D., Indianapolis, Ind.

Blocks, Tackle
Williamsport Wire Rope Co., Williamsport, Pa.

Bodies, Meter Box
Clark Co., H. W., Mattoon, Ill.

Bodies, Truck
Anthony Co., Streator, Ill.
Lee Trailer & Body Co., Plymouth, Ind.
Wood Hydraulic Hoist & Body, Detroit.

Boilers, Steam
Orr & Sembower, Reading, Pa.

Boilers, Steel
Central Foundry Co., New York City.
Cole Mfg. Co., R. D., Newman, Ga.

Bolts, Nails, Nuts, Riverts & Spikes
Ryerson & Son, Joseph T., Chicago.

Books, Engr. and Tech.
Gillette Publishing Co., Chicago, Ill.

Bowls, Cast Iron
Fulton Iron Works Co., St. Louis, Mo.

Boxes, Annealing
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Boxes, Meter
Clark Co., H. W., Mattoon, Ill.
Jas. B. Clow & Sons, Chicago, Ill.
Reading Meter Repair Co., Reading, Pa.

Braces, Trench
Jas. B. Clow & Sons, Chicago, Ill.
Kalamazoo Fdry. & Mach. Co., Kalamazoo, Mich.

Brands, Tool
Chicago Pneumatic Tool Co., New York City.
Independent Pneumatic Tool Co., 256 So. Jefferson St., Chicago, Ill.
Ingersoll-Rand Co., New York City.

Breakers, Paving
Gardner Denver Co., Denver, Colo.

Breechings, Steel
Cole Mfg. Co., R. D., Newman, Ga.
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.
Littleford Bros., 454 E. Pearl St. Cincinnati, O.

Brick
Hydraulic-Press Brick Co., St. Louis, Mo.
National Paving Brick Mfrs. Assn., Washington, D. C.

Brick, Enamel
Hydraulic-Press Brick Co., St. Louis, Mo.

Brick Loaders and Unloaders
Haiss Mfg. Co., Geo., New York City.

Brick, Mosaics
Hydraulic-Press Brick Co., St. Louis, Mo.

Brick, Paving
National Paving Brick Mfrs. Assn., Washington, D. C.

Brick, Salt Glaze
Hydraulic-Press Brick Co., St. Louis, Mo.

Brick Testing Machines
Tinius Olsen Testing Machine Co., 504 N. 12th St., Philadelphia, Pa.

Brick, Vitrified
National Paving Brick Mfrs. Assn., Washington, D. C.

Bridges
Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.

Bridge Accessories
Alan Wood Steel Co., Conshohocken, Pa.
Amer. Pressed Steel Co., Phila. Pa.

Bridge Planking
Servicised Premoulded Products, Inc., 53 W. Jackson Blvd., Chicago, Ill.

Bridges, Suspension
Roebling's Sons Co., John A., Trenton, N. J.

Brinell Hardness Testers
Tinius Olsen Testing Machine Co., 504 N. 12th St., Philadelphia, Pa.

Buckets, Back Filling
Garst Mfg. Co., Chicago.

Buckets, Clam Shell
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Haiss Mfg. Co., Inc., Geo., New York.
Hayward Co., New York City.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Orton Crane & Shovel Co., Chicago, Ill.
William Co., G. H., Erie, Pa.

Buckets, Concrete
Insley Mfg. Co., Indianapolis, Ind.
Ransome Concrete Mchry. Co., Dunnellen, N. J.

Buckets, Contractors
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Buckets, Dragline
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Bucyrus-Erie, So. Milwaukee, Wis.
Harnischfeger Corp., Milwaukee Wis.
Hayward Co., New York City.
Monighan Mfg. Corp., Chicago Ill.
Williams Company, G. H., Erie, Pa.

Buckets, Dredging and Excavating
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Bucyrus-Erie, So. Milwaukee, Wis.
Garst Mfg. Co., Chicago.
Haiss Mfg. Co., Inc., Geo., New York
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Marion Steam Shovel Co., Marion, Ohio.
Osgood Company, Marion, O.
Sauerman Brothers, Inc., 428 S. Clinton St., Chicago, Ill.
Smith Co, The T. L., 1031 32nd St., Milwaukee, Wis.
Williams Co., G. H., Erie, Pa.

Buckets, Excavating
Bucyrus-Erie, So. Milwaukee, Wis.
Haiss Mfg. Co., Geo., New York City.
Harnischfeger Corp., Milwaukee, Wis.

Buckets, Orange Peel
Hayward Co., New York City.
Williams Co., G. H., Erie, Pa.

Buckets, Self Filling
Pioneer Gravel Equipment Co., Minneapolis, Minn.

Building Paper
Barrett Co., New York City.

Building Steel
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Bulldozers
Baker Manufacturing Co., The, 506 Stanford Ave., Springfield, Ill.
Trackson Co., Milwaukee, Wis.
Western Wheeled Scraper Co., Aurora, Ill.

Burners, Furnace
Aeroil Burner Co., Inc., West New York, N. J.
Hauck Mfg. Co., Brooklyn, N. Y.

Bushings, Cast Iron
Fulton Iron Works Co., St. Louis, Mo.
Jas. B. Clow & Sons, Chicago, Ill.

Busses, Motor
Sterling Motor Truck Co., Milwaukee, Wisc.

Cableways
American Steel & Wire Co., Chicago.
Hayward Company, New York City.
Sauerman Brothers, Inc., 428 S. Clinton St., Chicago, Ill.

Cableway Excavators
(See Excavators, Cableway.)

Cabs, Motor Truck
Highland Body Mfg. Co., Cincinnati, Ohio.

Calcium Chloride
Calcium Chloride Publicity Committee, New York City.
Columbus Products Co., The, Barberton, Ohio.
Dow Chemical Co., Midland, Mich.
Grasselli Chemical Co., Cleveland, Ohio.
Semet-Solway Co., 61 Broadway, New York, N. Y.
Solvay Sales Corp., New York City.

Calking Machines
Chicago Pneumatic Tool Co., 6 East 44th St., New York City.
Independent Pneumatic Tool Co., 256 S. Jefferson St., Chicago.
Ingersoll-Rand Co., New York City.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Capstans, Windlasses and Winches
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Bay City Fdy. and Machine Co., Bay City, Mich.
Fulton Iron Works Co., St. Louis, Mo.

Car Steps, Safety
Alan Wood Steel Co., Conshohocken, Pa.
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Cars, Rwy.
Fairbanks Morse Co., Chicago, Ill.
Western Wheeled Scraper Co., Aurora, Ill.

Cars, Industrial V Dumps
Insley Mfg. Co., Indianapolis, Ind.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Carts, Concrete
Insley Mfg. Co., Indianapolis Ind.
Ransome Concrete Mchry. Co., Dunnellen, N. J.

Casting Testing Machines
Tinius Olsen Testing Machine Co., 504 N. 12th St., Philadelphia, Pa.

Casings, Well
Armco Culvert Mfrs. Assn., Middletown, O.

Castings, Builders
Clark Co., H. W., Mattoon, Ill.

Castings, Buildinn
Fulton Iron Works Co.. St. Louis. Mo

Castings, Grey Iron
Fulton Iron Works Co., St. Louis, Mo.
National Cast Iron Pipe Co., Birmingham, Ala.

Castings, Iron & Steel
Central Foundry Co., New York City.
Central Iron & Steel Co., Harrisburg, Pa.
Clark Co., H. W., Mattoon, Ill.
Cole Mfg. Co., R. D., Newman, Ga.
Klauer Mfg. Co., Dubuque, Ia.
McWane Cast Iron Pipe Co., Birmingham, Ala.
Marion Steam Shovel Co., Marion.
National Cast Iron Pipe Co., Birmingham, Ala.
Ohio.
Pacific States Cast Iron Pipe Co., Provo, Utah.
Riddell Co., W. A., Bucyrus, O.
Smith Steel Casting Co., Geo. H., Milwaukee, Wis.
South Bend Fdy. Co., South Bend, Ind.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
Western Crucible Steel Casting Co., Minneapolis, Minn.
Wood, R. D. & Co., Philadelphia, Pa.

Castings, Municipal
Clark Co., H. W., Mattoon, Ill.
Fulton Iron Works Co., St. Louis, Mo.
National Cast Iron Pipe Co., Birmingham, Ala.
U. S. Pipe & Foundry, Burlington, N. J.

Castings, Semi-Steel
Fulton Iron Works Co., St. Louis, Mo.

Castings, Street and Sewer
Central Foundry Co., New York City.
Clark Co., H. W., Mattoon, Ill.
Clow & Sons, James B., 201-299 N. Talman Ave., Chicago, Ill.
Klauer Mfg. Co., Dubuque, Ia.
South Bend Fdy. Co., South Bend, Ind.
U. S. C. I. Pipe & Fdy. Co., Burlington, N. J.
Wood & Co., R. D., Philadelphia, Pa.

Catch Basins, Corrugated Iron
Armco Culvert Mfrs. Assn., Middletown, Ohio.

Catch Basin Covers
Central Iron & Steel Co., Harrisburg, Pa.
Clark & Co., H. W., Mattoon, Ill.
Jas. B. Clow & Sons, Chicago, Ill.
Galion Iron Works, Galion, Ohio.
U. S. Pipe & Foundry Co., Burlington, N. J.

Celite
Johns-Manville Corp., New York City.

Cement
Carey Co., Philip, Cincinnati, O.
Mo. Portland Cement Co., St. Louis, Mo.

Cement Guns
Cement-Guns Construction Co., Inc., Chicago, Ill.

Cement-Making Machinery
Allis-Chalmers Mfg. Co., Milwaukee.

Cement Laboratory Equipment
Tinius Olsen Testing Machine Co., 504 N. 12th St., Philadelphia, Pa.

Cement Moulds
Tinius Olsen Testing Machine Co., 504 N. 12th St., Philadelphia, Pa.

Cement Testing Machines
Tinius Olsen Testing Machine Co., 504 N. 12th St., Philadelphia, Pa.

Centers, Steel, Collapsible
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Chain Testing Machines
Tinius Olsen Testing Machine Co., 504 N. 12th St., Philadelphia, Pa.

Chain, Steel & Malleable
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.

Yes—we would like you to mention WATER WORKS AND SEWERAGE.

Water Works and Sewerage

Vol. LXXVII MARCH, 1930 No. 3

Putting Down the Piling for the Cofferdam for the Cherry Creek Crossing

Denver Installs New Water Conduit

Construction Features of New 8-Mile 60-In. Pipe Line That Will Cost $1,300,000

By JOS. C. COYLE

THE latest improvement in Denver's $23,000,000 water works system is nearing completion at this writing and will help carry the peak of the 1930 water consumption. This is an 8-mile installation of 60-in. reinforced concrete conduit connecting the Capitol Hill pumping station with Wynetka Junction. From the university park station to the Capitol Hill station it replaces a 20-year-old 48-in. conduit, partly of wood and partly of steel. The purpose of the line is to augment the water supply brought in by other conduits from filters near Wynetka. The total cost of the line is $1,300,000.

A number of adverse conditions along the line of construction, swamps, hard rock, two river crossings and a mile of frozen ground that had to be blasted to a depth of 3 to 5 ft., made the installation an interesting and difficult one. Several hundred yards of swamp just west of the Platte River gave considerable trouble, both in timbering and water removal. The first was overcome by the use of a heavy unit of shoring to hold the banks while sections of the pipe were installed. This shoring was placed and removed as the work progressed by the machine used for excavating. A large scraper, operated by the same machine, backfilled the trench after a stretch of the pipe was laid.

The water problem was solved by the use of three extra 5-in. centrifugal pumps, direct connected to used automobile engines for power. The frames only were used with these engines, being cut down in length with acetylene torch and braces welded on by which to lift the outfits with a crane.

Pull shovels were used in excavating by the two construction crews, one doing both excavating and laying of pipe while a crawler crane placed the pipe and back filled for the second crew. The width of the trench was usually 8 ft., and the depth from 9½ to 15 ft. At the crossing of the Platte River a cofferdam of interlocking steel piling 18 ft. wide and 103 ft. long was driven to bedrock and the gravel removed from the inside, while two of the large centrifugal pumps kept the seepage water under control. The bed rock of blue serpentine was drilled and blasted to a depth of 8 ft. The pipe was laid for the length of the cofferdam, being drawn together with a chain attached to a steel bar across the back end of each joint, and to a hand wheel at the front end, while the section was suspended on a wire cable and manipulated by a small block. The pipe was covered with concrete to a depth of 2 ft., the 103 ft. section was

Rock Excavation at Railroad Overhead Crossing

backfilled and the operation repeated twice, making the total length of the river crossing 309 ft.

Two railroads and a highway, near the Platte River crossing, were crossed through concrete culverts in a small ravine. The three culverts were near each other and at this point the excavation was almost entirely in sandstone, necessitating blasting. Two drills were operated from a portable compressor. The holes were slanted at about 45 deg. toward the excavation. In blasting directly beneath the culverts two lifts, with light charges of dynamite, were employed, to avoid damage to the structures. Very close work was required of the pull shovel at these culverts, as there was only about 6 in. clearance between it and the arch, and the shovel was obliged to back out of the culverts to dump each shovelful of rock. Six inches of concrete was poured over the top of the pipe after laying, for some distance on each side of the tracks.

In the latter stages of construction unusually severe weather prevailed for weeks, although only one day's time was lost by the crews. For a time the surface of the ground was thawed ahead of the machines by covering with arched sections of heavy sheet metal and introducing flames from a blow torch at one end. Finally, however, the freeze became so deep that blasting was resorted to in breaking through the last mile of ditch. Three rows of holes, 2½ ft. deep and 3 ft. apart each way, were drilled. These were loaded with 1½ sticks of 40 per cent gelatin dynamite and three holes at a time were fired by the shovel operator, using electric wiring from the holes to the machine. Several rounds were fired in this way, the shovel being used to place a 6x12-ft. wooden mat over the shots as the firing progressed, and the shovel then returned to removing the loose dirt.

Wherever rock was encountered the pipe was laid on a 2-in. cushion of screened sand, to protect it from sharp edges of projecting stones. As much as 300 ft. of pipe per day was laid by one crew in the better going. A special plant was erected near the job, by the Lock Joint Pipe Co., the contractors, for manufacturing the pipe. Quick-sand occasioned some trouble at the crossing of Cherry Creek, but the use of the steel cofferdam with two 5-in. pumps overcame the difficulty.

D. D. Gross is chief engineer of the Denver, Colo., Water Department and H. R. Oliver was engineer in charge of the pipe line construction. W. W. Trickey was in charge of both manufacturing and installation for the Lock Joint Pipe Co.

Meeting of Arizona Public Health Association.—The third annual meeting of the Arizona Public Health Association will be held at the Adams Hotel, Phoenix, Ariz., on April 22 and 23, under the auspices of the State Board of Health. Health officers, city engineers, water works and sewage plant operators, dairy inspectors, public health nurses, and all others actively interested in community health and sanitation are cordially invited to attend this meeting. The committee is arranging an interesting program with special sessions for health officers, dairy inspectors, and water and sewage plant operators. Jane H. Rider, Box 167, University Station, Tucson, Ariz., is secretary.

Suggestions for Improving Public Service.—City Manager Sherrill of Cincinnati enclosed with each water bill recently mailed to citizens a postcard asking for suggestions as to how to better the public service. Several thousands of them were returned with helpful replies.

Firing a Round in Frozen Ground Ahead of the Shovel

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor
Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

Planning Ahead for Plant Development

Having been much interested, during the past 15 years in:

(1) Improving the general fund of knowledge with regard to the subject of sewage disposal;

(2) Improving the status of the sewage plant operator;

(3) Training the operator up to the improved status:

The writer once more harks back to the matter of records of operation with the thought that such records may well be the basis of a program for future plant development; a program the economies of which will more than repay the municipality for all salary paid to a trained and efficient operator.

Our general fund of knowledge of the subject of sewage disposal has now progressed to the point where the designer of a sewage works can not feel that he has fully discharged his duty to the municipality by merely providing excessive capacities in the various units based on a predicted population 15 or 20 years hence.

In the first place, with the swiftly changing conditions of our American life, the development of new industries and the diversion of old industries to new fields (geographically) in search of better labor conditions, or to be nearer to sources of power or raw material, such predictions are seldom reliable.

Either we overbuild a plant up to which the community may never grow or due to underestimation we locate the disposal works at a point which long before its capacity is reached becomes untenable due to the encroachment of population upon it.

I recall a statement made many years ago by a railroad executive that, concrete was not a suitable construction material for round houses because it is too durable. The thought was, of course, that the march of progress frequently called for the destruction of such round houses and that the cost of demolition was excessive. Unfortunately, conditions under which sewage disposal works are built, and used, call for rugged design and construction although the life of the plant in any progressive part of the country is decidedly limited.

Aside from the difficulty of predicting probable growth of connected population and development of areas adjacent to disposal plant sites there is the problem of whether or not the present available methods of disposal and purification will either meet the demand or prove to be economical 15 or 20 years hence. Yet, on the other hand, there is the immediate necessity of providing sewage treatment in order to clear up our streams to the best of our ability and in the light of our present knowledge.

The custom of designing sewage treatment plants on the basis of a predicted population from 15 to 40 years hence is a natural outcome of good engineering practice in the design of other public works. Then, in addition to this consideration, there is the feeling that it is comparatively easier to secure a large sum of money for a sort of monumental work with the promise that such expenditures will not have to be repeated within an ordinary lifetime than it is to secure repeated smaller sums to build enlargements. Also many engineers feel that by providing excessive capacities based on a time quite distant, they can rest assured that at least immediate results will prove satisfactory with appropriate credit to themselves.

Here, again, sewage proves itself to be somewhat of an exception to accepted ideas of dealing with public works and the very excess capacities provided as a margin of safety may prove to be a boomerang by becoming odor producers.

From the economical point of view the designing of sewage plants for the distant future results in the tying up of municipal funds over a very long period of time in structures, some of which, for reasons already pointed out, may never become useful and will simply clutter up the disposal plant site. It is also true that a comparatively few persons have carried the burden of taxes to pay principal and interest over the years for the benefit of the far greater number who may or may not make use of the facilities at the end of such period. Though, theoretically, this sacrifice of the few will have been counterbalanced by the increased value of the properties owned by them, the writer believes that in practice the loss is actual.

Certainly, if, as is often the case, the adopted system becomes obsolete or the site becomes untenable, before the demands reach the constructed capacity the economic loss is tremendous.

From the operating point of view flexibility is a prime requirement, which is best met by a multiplicity of small units as compared with single large units. Such small units may also be capable of use for one of two or several purposes, as occasion may demand.

By the use of such small units designed for a reasonable immediate future demand, the capital investment is kept down and the plant may be expanded along the most useful lines as operating experience may dictate to be necessary to meet possible changing industrial demands, etc.

In building the plant gradually to meet the demands as they arise instead of building the plant in bulk to meet hypothetical future demands we not only eliminate much loss in interest but also much loss by deterioration which is very high in a sewage disposal works and especially so in idle parts of such works.

While it most certainly seems foolish to pay interest charges on structures which will not be used for many years and which during those years may become useless due to deterioration, changing conditions, or obsolescence, there is just as certainly much food for thought in the statement that it is easier to secure funds for the whole works at one time than to keep coming back for small sums. Moreover, the securing of funds for additions in the future years is highly problematical under present systems of financing in which the sewer department has to compete with all the other departments, many of which are much more popular, for a share of the annual municipal budget.

Fortunately, we are rapidly passing out of that era in which engineers assumed to design foolproof plants which could be built, started and forgotten. In fact through the agency of various organizations, some connected with matters of sanitation and some with sporting or merely ethereal interests

we have become educated up to a point where the sewage plant is no longer among things best forgotten.

It now becomes necessary to carry this matter of education forward to the realm of sane financing. The sewer rental laws and direct sewer assessment laws of Ohio and several other states make it possible in those localities to plan ahead for a comprehensive development program to meet actual conditions as we approach them, and to do this with confidence that funds will be available when required.

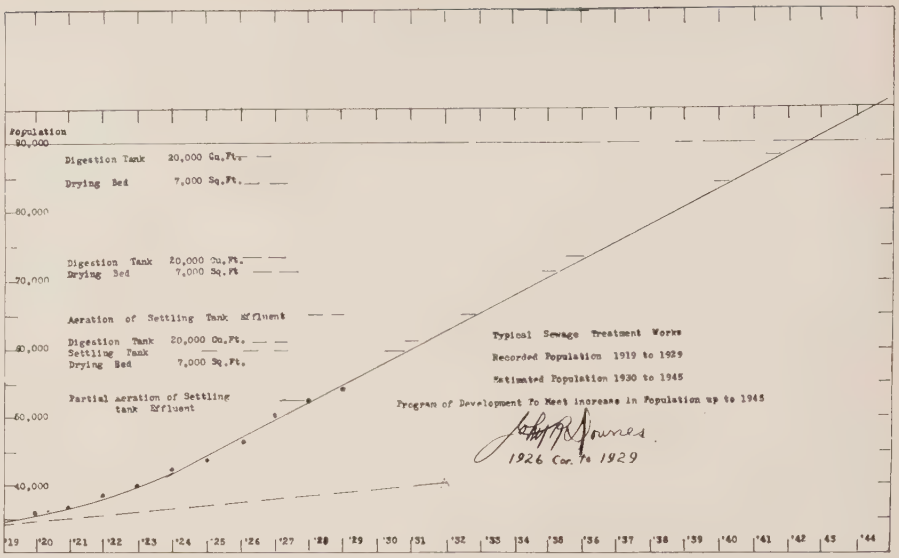
State health authorities would not be justified in approving plans for such deferred development except when assured and satisfied that an adequate financing program had been worked out and put into operation on an irrevocable basis which would preclude diversion of the funds.

The nature of the problem in sewage treatment and particularly this matter of financing, demand the continued sympathetic interest of a stable board of directors, whereas, the usual practice is to put the direction of sewer affairs into the hands of a councilmanic committee the personnel of which is constantly changing. The writer's experience has indicated very clearly the superior working conditions which will obtain under a more or less permanent commission which retains office long enough to become really familiar with and interested in the subject. It would seem proper that state health authorities in approving plans for deferred development should take into consideration the form of organization under which the plan would be carried out.

Coming, now, back to the matter of the operator and his records it is necessary that these records shall show correctly the number of house connections, the flow of sewage, the weight and volume of suspended solids in the raw sewage and in tank effluents, quantities and condition of sludge handled and the relative degree of oxidation of the effluent of oxidizing devices, also records of condition of the sewage as it reaches the plant with regard to its freshness.

From such records we may establish a basis for design of additions to the plant to meet the demands of the immediate future and may predict the financial demands to cover a development program for a period of years to follow. If population growth becomes retarded or accelerated, or if new industries impose new demands the program is sufficiently flexible to meet the changed conditions without any actual monetary loss.

The accompanying graph shows at a glance the proposed building program to meet the normal demands at a given



Program of Development of a Typical Sewage Treatment Works to Meet Increase in Population Up to 1945

typical plant provided that the controlling conditions remain in line with those prevalent today. How far this prediction may be from the facts which may develop in the future is indicated by the lower dash line which shows the prediction for the population of the same area projected in 1912 on the basis of developments during the previous 15 years both in this and several other corresponding areas.

The particular plant for which the graph was made consists of: Mechanical screens, sedimentation tanks, separate digestion tanks, trickling filters and humus tanks. The connected population was approaching 50,000 and the trickling filters were approaching their capacity. As a result of previous experimental work partial aeration of the settling tank effluent was introduced in 1927-28 with decided beneficial effect of the trickling filters. Additional facilities for aeration will be required, as shown, in about 1932 though the exact requirements have not been worked out.

For purposes of comparison let us assume some arbitrary unit costs and examine the financial possibilities over the 15-year period 1927 to 1942.

In the table and calculation it was assumed that if the enlargements had been built in 1927 the cost would have been amortized over the succeeding 15 years and that under the deferred construction program, a sum equal to the annual payments on principal would be collected and added to the construction fund.

In addition to this economy it may be said that there would be an additional saving of 50 per cent in this case due to the definite information available from the records of the operator which make it possible to design to accurate needs rather than to some arbitrary rule of thumb.

Unfortunately there are few places at the present time in which such a plan could be carried out under existing laws and conditions. However, let us put every plant in charge of an operator capable and equipped to secure such data; and let every operator keep this goal in mind.

Comparison of Costs of Building Additions to an Existing Sewage Treatment Works to Cover the Requirements of the Next 15 Years as Indicated by Operating Data Over the Past Ten Years

Comparison Between Cost of Complete Equipment Built in 1927; and Costs When Different Small Units Are to Be Built as Required

Year	Payments Principal	Payments Interest	Costs Items	Costs Cumulative	Income Accumulated	Difference	5% Interest
27	7,733	5,805	1,000	1,000	7,733	.....	.....
28	7,733	5,418	.....	.....	15,466	.....	.....
29	7,733	5,031	.....	.....	23,199	.....	.....
30	7,733	4,644	27,000	28,000	30,932	.....	.....
31	7,733	4,257	9,000	37,000	38,665	.....	.....
32	7,733	3,870	.....	.....	46,398	.....	.....
33	7,733	3,483	25,000	62,000	54,131	7,869	393.45
34	7,733	2,856	.....	.....	61,864	136	6.80
35	7,733	2,709	18,000	80,000	69,597	10,403	520.15
36	7,733	2,322	9,000	89,000	77,330	11,670	583.50
37	7,733	1,935	.....	.....	85,063	3,937	196.85
38	7,733	1,548	.....	.....	92,796	.....	.....
39	7,733	1,161	.....	.....	100,529	.....	.....
40	7,733	774	18,000	107,000	108,262	.....	.....
41	7,733	387	.....	.....	115,995	.....	.....
42	.....	.....	9,000	116,000	.....	.....	.....
	$115,995	46,199	116,000	.....	115,995	.....	$1,700.75

Interest saved $46,199.00
Plus interest credit 2,838.55
Total saving by deferred building .. $49,037.55

Interest credits @ 5% $4,539.30
years when fund ahead
Net interest credit 2,838.55

The Water Works Manager's Job

An Interesting Outline of the Responsibilities and Principal Duties of the Manager of a Water Company

By W. C. HAWLEY

Chief Engineer and General Superintendent, Pennsylvania Water Co., Wilkinsburg, Pa.

THERE is no person in a community who renders to that community a more important service than does the manager of the local water utility. On him rests the responsibility, to a large extent, for the comfort, health and safety of the community. Of course he serves under a board of water commissioners or a board of directors, but the responsibility rests directly on his shoulders. If you doubt that statement spend an hour or two in his office some day when the force or supply main has burst and the town or a part of it is without water. Or drop in some day an hour or two after the man has gone out to shut water off from those who have not paid their water bills. Go with him some winter night when a big fire is in progress and the demand for water for fire protection approaches the capacity of the water works system. These experiences will give you some idea of the load he carries on his shoulders. He may spend only eight or nine hours per day in his office, but the responsibility is his, day and night, and seven days in the week. He may be called out of bed any time of night by the ringing of the 'phone to learn that the main on Broadway has "busted" or that there is a big fire on Second Street. When the 'phone rings at 2 a. m. and a voice asks, "Is this Dr. Jones?" he replies with a smile, "You have the wrong number" and when the voice says "I am sorry," he answers cheerily, "Don't mention it." And that's because he is so glad that it wasn't the engineer to tell him that No. 1 pump has a cracked cylinder or the night man at the office to say that an automobile has knocked over a fire hydrant and water has flooded various cellars.

Since our association is made up of water companies this paper will not consider the managers of municipally-owned water plants.

Three Major Responsibilities.—The manager of a water company has three major responsibilities:

To the company's stockholders, represented by their officers and board of directors.

To the public, represented by individual consumers, the municipal authorities and the public service commission, and

To the employes of the water company.

The question at once arises, "To which of these groups is he bound to give preference in service and loyalty?" In the old days this question would have been answered that his duty and loyalty were first to the company and its stockholders. I believe, however, that with our present ideas of public service the answer would be that the company, the public and the employes have a mutuality of interest, but that service to the public comes first, but it can be given only by building up an efficient organization of loyal employes, inspired by the idea of service and that the interests of the company are best served when the plant and the employes are giving to the public such good and satisfactory service as it has the right to expect.

Organization of the Employes.—The manager's first task, therefore, is to build up an organization of employes whose effiicency, enthusiasm and loyalty will result in such good service to the public that it will insure to the company and its stockholders the good will of and kindly relations with the public and a reasonable return. He must choose as members of the organization those who understand or at least those who can be taught and will try to understand their respective tasks and to perform their duties with credit to themselves and to the company. Special care must be exercised in the choice of those employes who come in contact with the public,—the clerks, meter readers, inspectors and particularly those who use the telephones. "Put a smile in your voice" is a good rule for a telephone company and it is just as good for a water company. A manager should not only insist on absolute courtesy in meeting the public,—he should employ only those who are naturally courteous. A cloak of assumed courtesy is too sure to be thrown off upon provocation and there is plenty of provocation in dealing with the public.

One of the fundamental problems of the manager is the creation and maintenance of an esprit de corps in his organization which insures absolute loyalty to the company and harmony among the employes. Water works service is a difficult service. It must be maintained 24 hours per day and seven days per week. Accidents, breaks, etc., may happen any time of day or night. Repairs must be made under all sorts of weather conditions and every effort made to maintain service or to renew it at the earliest possible moment. How shall he inspire the loyalty and devotion necessary to carry on? A prominent speaker recently said that industry is rapidly discarding the use of the word "hands" as applied to its employes. This is probably true, except on the farm, and perhaps that is one of the difficulties with our agricultural industry. Employes are being treated more and more as human beings. More consideration is being given to the comfort, health and welfare of the employes and those dependent on them. The number of hours per day and the number of days per week are being reduced, wages and salaries increased, working conditions improved, provisions made for group and co-operative insurance, sick benefits or part time payment during sickness, as well as nursing or hospital service. Vacations with pay are rapidly coming into favor. Pensions are provided for employes who have given long and faithful service and for those who have been incapacitated during employment. By such methods, the cost of which a live, up-to-date board of directors should be glad to authorize, a spirit of hearty loyalty and self-sacrifice where necessary can be built up among a corps of employes that will be well worth all it costs and which, of course within reasonable limits, the company has a right to charge to operation and to expect its consumers to pay as part of the cost of good service.

Operating Problems.—A manager's operating problems are many and varied. It is impossible to say which is of the greatest importance. One duty that is ever present is that of keeping the plant equal to any reasonably foreseen demand that may be made upon it. In designing a water works plant liberal allowance is always made for growth of the district served. Careful study should be made of the changes in population in the past and estimates made of increases to be expected in the future. It is the manager's task as new demands are made to increase capacity and extend facilities as may be necessary. Plans must be made so that service can be maintained while certain units are down for repairs. Watch must be kept of the condition of existing units and as a unit approaches the end of its useful life a new one should be installed. He should not wait until the unit in service breaks down before providing for its replacement.

Extensions to the distribution system are among the most difficult and puzzling problems which the manager encounters. This matter has been discussed at previous conventions and

there is little to be added at this time. Our Public Service Commission has laid down no rule which can be followed but it has, in recent years, handed down fewer decisions which appear to the water works man to be unfair than it did in the early days of the commission. In the light of experience since the previous discussion of this subject I would call attention to the necessity for considering not only the investment in pipe extensions, service lines and meters necessary to reach properties demanding service, but also something to represent investment in general plant necessary to serve. In many cases where extensions have been made the revenue will not be sufficient for years to come to carry more than the investment in the extension alone and in some cases not that.

Accounting.—A manager should keep in touch with the accounting of his company. Years ago when the classification of accounts for water companies was given us by the Public Service Commission there were many who thought that it was unnecessarily elaborate and involved. To some of the smaller companies it may be a burden but I think in general, the larger companies find it helpful and well worth all the trouble and expense which it causes.

In the classification prepared by the Public Service Commission the distribution of expenses is made by a system of numbers. It is easy to make mistakes in such a system. The memory will not always choose the right number and figures will be inverted. It is believed that a voucher distribution system using letters with only a few numbers, and those numbers having definite meanings, is less liable to result in error than a system of numbers. For instance, the letter C can be taken to mean "construction" or "additions to plant account"; O—"operating"; E —"expense"; M—"maintenance," etc. Numbers would be used to indicate units or structures known by number. For instance, "CR2" would mean an item chargeable to "construction of reservoir No. 2" and "MP3" would mean "maintenance of pump No. 3." This means that the particular item is associated with the structure or the unit to which it is chargeable.

Rules and Rate Schedules.—There is nothing more important to a water company than that its rules shall be reasonable, comprehensive and so well stated as to be readily understandable to people of ordinary intelligence. The same applies to its rate schedule. Unless it has such rules, one of the first jobs of the manager should be the preparation of new rules to be properly adopted, filed and posted. Many of the company members of our association have adopted new rules within recent years. Those that have not should give the matter serious consideration.

Since beginning the preparation of this paper there has been received the decision of the Public Service Commission in the case of the Borough of Snow Shoe, et al. vs. the Snow Shoe Water Co., decided by the Public Service Commission Dec. 21, 1928. In this decision will be found a rate schedule and a set of rules which the water company in that case was ordered to file, post and publish, which will be of great assistance to any water company revising its rules and rates. The rules in particular have evidently been prepared with great care and thought and in many respects are an improvement over the rules now in force by most of the water companies of the state. There are a very few things in them which the experienced water works operator will realize as at least doubtful but they will serve as an excellent model to any water company that is rewriting or amending its present rules.

Enforcement of Rules.—Then follows the reasonable enforcement of the rules. No consumer should be told that he "has to" or "must" do a thing because the rule says so. If the rule is a reasonable rule the consumer is entitled to the explanation and with an intelligent consumer this is generally sufficient and not only that, he goes away with the impression that the company's rules are not arbitrary but that there is a reason for them, and if he has been courteously treated he is likely to spread the good news. Every effort should be made to avoid discrimination or preferential treatment of consumers. It is sometimes difficult to refuse a request of a prominent citizen or a politician or a personal friend but if the manager refuses a request made by Smith and Smith then shows that he has done the same thing for Jones, the manager finds himself in an embarassing position. If that sort of thing continues his rules will be of little use to him.

Employes should be familiar with the rules and should understand the reason for every rule and so far as possible, its application, so that they can explain the rules and their enforcement to those who make inquiry or who may object to some enforcement of a rule or rules. Nothing makes a consumer more angry than to have some clerk or other employe who evidently can give no reasonable explanation of some method of doing business or of some rule, act in an arbitrary manner or put up a bluff. We have enough trouble without creating more by such conduct on the part of our employes but it seems hard for some of them to realize when they do not know the answer to a question and harder still to admit it and call on some other employe who does know and can make a reasonable presentation of the matter to the customer. Such an employe should either be discharged or put in a position where he will not have to meet the public.

Relations of Company to City Served.—The relations of a water company to the municipality which it serves and to the municipal officers are very important. The attitude of the municipal authorities generally reflects the attitude of the community toward the water company. If the service is good, the treatment of patrons courteous and the rates reasonable, the people of the community are generally friendly. If not, the dislike of the people for the water company will be reflected in the attitude of council and other officers. There are other factors such as the attitude of the local paper or papers and some times there are politicians who think they can make political capital by attacking any public utility. In recent years where there have been differences, an effective way of settling them has been to arrange for a meeting where the differences can be frankly discussed and the water company can lay its cards on the table and explain its position. Such a method is at least worth a trial, but the manager must be very sure of the reasonableness of his position and be able to present the reasons for it in a way that will be appreciated by the representatives of the municipality.

The Pavement Problem.—A problem which is causing water works managers much trouble at the present time is the laying of pavements, especially concrete or with concrete foundations. Naturally there are objections to opening such a pavement for laying service lines, etc., and yet it is sometimes necessary. It is up to the manager when a pavement must be opened, to see that it is replaced in such a manner that the pavement is not damaged in any way. It is impossible to foretell where a service line will be needed or what size will be needed and the Public Service Commission has refused to compel a water company to install service lines before paving. Service lines and mains will sometimes leak and hence it is necessary to cut through pavements, but the municipality is right in its insistence that as few openings as possible shall be made and that the ditches shall be back-filled and the pavement replaced properly.

The more personal friends the manager has the better will be the standing of the water company among the people that it is serving. He should take a part in all civic activities such as the chamber of commerce or board of trade, business men's association, etc., and in one of the service clubs. His activities in such matters will make friends for the water company.

Importance of Records.—He should keep records showing the increase or decrease in plant account, income and expenses, taps—active and non-active, meters, pipe lines, valves, fire hydrants, etc. Such records can best be used for comparison if plotted on a cross section paper. I strongly suspect that if such records were kept they would

show that in most cases in recent years plant account has been increasing at a rate much exceeding the rate of increase of net revenue. This will be especially true of those plants where it has been necessary to increase investment in general plant such as pumping machinery, reservoirs, supply mains, etc., for there is no corresponding increase in consumers.

Meter Readings.—Special attention is called to the matter of meter reading and the information to be gotten and recorded by the meter readers. The meter reader should be a young man of some education, absolutely courteous, who takes an interest in his job. He should be carefully instructed in his duties and his work checked closely enough to know that he is carrying out his instructions. He should not only read the meter carefully and check to make sure that he is right, but he should get such other information as to leaks or other reasons for unusually large registration, etc., as he can, and that information should be recorded on the meter sheet. The meter book when returned to the office should be gone through carefully and any indication of a meter being out of order and not registering or of excessive consumption should be recorded and the man who is sent out to get the "aways" should check the condition of reading of the meters listed, and get any other pertinent information. By such methods mistakes are avoided and the information obtained is worth all it costs and more. Frequently when a consumer objects to the payment of a large bill, declaring that there has been no leak or other reason for unusually large registration, a reference to the meter book which shows that there was a leak in a certain fixture or that gives other definite information will end the argument. On each meter sheet there should be a record of the date of the last test of the meter and the reading at the time of that test. From these records it is readily seen when the meter should be tested in compliance with the rule of the Public Service Commission.

Valve Records.—Records should be kept of the operation of valves, each operation being reported on a report form giving date, time, name of person operating and reason. There should be regular tests of both valves and fire hydrants to see that they are in proper operating condition. This is the only way that one can be sure that the valves are all open or that the fire hydrants are in proper condition to operate. It is especially necessary as to fire hydrants in these days of automobiles.

On every water works plant of any size there should be installed a pressure recording gauge and, on large plants, two or more as may be necessary. The records of such a gauge will be of great value as indicating the adequacy or inadequacy of distribution system or supply main or in case of fire and a charge of low pressure they tell just what happened. They will show when a break occurred and how long it took to close the valves and restore normal service.

A water company is able to economize in the purchase of many of the supplies entering into its plant to a greater extent than is possible to a municipally-owned water works system. It can standardize on such items as valves, fire hydrants, service line materials and meters. In this way it avoids carrying a multiplicity of repair parts and by choosing the best, can save in costs of maintenance. There is no reason for installing half a dozen different makes of valves for instance and having to carry repair parts for all these different makes. There is no reason for having fifteen or twenty different kinds of meters. A first-class meter, or at most three or four, can be chosen as the result of experience and adopted as standard. A meter so chosen can be purchased as cheaply or even at a lower price than could be obtained for a good meter in competition and the saving in cost of repair parts to be carried and in the cost of storing them and keeping account of them is well worth while.

Adjusting Bills.—One of the water works manager's most trying problems is that of adjusting bills for consumers when the meter has been out of order or stopped registering during all or a part of the period for which the bill is made. Anyone who has had experience knows that there is no hard and fast rule that can be applied. The rules approved for the Snow Shoe Water Co. previously mentioned provide: "The quantity of water consumed shall be estimated by the average registration of the meter on previous corresponding periods." Such a rule is about a one to five shot. That is, it may apply in one case out of five. If the same number of people are occupying the property, if there has been no unusual waste or leakage and conditions generally are the same, it is an excellent method, but any change in the number of persons supplied, the difference between a wet and a dry season where lawns are sprinkled, etc., will render it of little value. Registration for a period of reasonable length immediately before or immediately after the time when the meter was out of order, or possibly an average of the two, will in many cases give a fairer result. One of the best methods is to plot the registration of the meter on cross section paper for a period of two or three years. This method will give information which is not readily observed from a study of the meter sheet and sometimes the information is surprising. In any case it is a matter of good judgment and the honest effort to arrive at a result that is fair to both consumer and water company. It must not be arbitrary but the method should be such that the reasonable consumer will be satisfied with it.

As has been said previously, the manager in giving good service to the public is best serving the stockholders and officers of the company which employs him. There are, of course, his duties in the preparation of reports, estimates, statements by which the directors are kept advised of the condition of the company and its activities and the good manager will consult his board of directors and ask for advice and aid in carrying out his work. He should receive the support, co-operation and assistance of the directors in all he undertakes.

This paper has touched on some of the principal duties of the water works manager, but there are many other minor duties that there is no time to discuss. He has many perplexing problems and some that are aggravating, but I know of no business that has the infinite variety of interesting questions and problems arising constantly. Mixed with this, too, there is a spice of humor, for many funny things occur in a water works office. It is this variety and the satisfaction of giving useful service that makes the water works manager's job so interesting and worth while. Under his direction millions of gallons of water are supplied to meet the vital needs of the community. Surely he should share in the blessings promised to him who gives a cup of cold water.

Acknowledgment.—The foregoing is an abstract of a paper presented at the last annual meeting of the Pennsylvania Water Works Association.

State and Municipal Bond Election Results During February

Bond authorizations reported by 76 municipalities during February aggregated $17,772,500, the largest total for February of any year since 1926, according to "The Daily Bond Buyer" of New York. The figure for February of last year was $13,309,998; for February, 1928, $8,204,600, and for January, 1927, $15,326,500.

A few of the larger authorizations last month were $6,230,000, Tulsa, Okla.; $4,000,000, Birmingham, Ala.; $850,000, High Point, N. C., school district, and $690,000, Clayton County, Iowa.

Proposed issues by 33 municipalities in 17 states, aggregating $7,861,993, were rejected by the voters as compared with $5,122,000 in February, 1929; $6,951,500 in 1928, and $4,963,500 in 1926. Among the larger projects defeated were $3,453,000, Phoenix, Ariz.; $500,000, Tulsa County, Oklahoma, and $492,000, Lawrence County, New Jersey, school district.

How Ancient History Throws Light on Weather Cycles

By HALBERT P. GILLETTE

VIGOROUS efforts are being made to determine the nature and length of weather cycles, and every scrap of evidence is being carefully reviewed. The varying thicknesses of the annual rings of trees for nearly 32 centuries, and the annual clay laminae, or "varves," deposited in ancient glacial lakes back for about 160 centuries are under rigorous analysis. Even ancient history has been summoned to testify as to weather, not merely through its occasional mentions of extraordinary storms, floods, or droughts, but through its more frequent accounts of great wars, migrations and colonizations.

It has gradually dawned upon a few researchers in the realm of meteorology that many, perhaps most great wars of early days were the direct result of severe climatic stress, and not the result of innate greed, animosity or bloodthirstiness. In Brooks' "Climate Through the Ages," several chapters are devoted to a brief review of early migrations. He gives approximate dates of these "waves" in the hope that they will cast light on the problem of climatic cycles, as well as to indicate that climate has certainly varied greatly during the past 50 centuries.

Study of rainfall, floods, tree-growth, clay varves, aurora, sunspots, earthquakes and volcanic eruptions had convinced the writer that there is a cycle of 633 years that is to be found in all of these phenomena; and that there are very important subcycles of one-third of 633 years, or 211 years. A cycle of about 210 years in the maximum floods of the Nile had been previously pointed out by del Valle, based on his study of the flood records back to 641 A. D. The greatest floods of the Nile occur when American and European rainfall is at a minimum, so, bearing this fact in mind, the writer saw that the del Valle cycle of about 210 years fits almost perfectly with his own discovery of the 211-year subcycle above mentioned.

The next step in testing the existence of the 633-year cycle consisted in comparing its calculated peak or maximum dates with historical records of migrations and wars. A few examples of the results of this study will be given.

Weather records had pointed strongly toward 1323 A. D. as a maximum or peak date of this 633-year cycle; so 3 cycles prior thereto brings us to 1209 B. C., which was about the time that the "Bronze Age" people of the Hungarian plain and the Phrygians migrated in "waves." Brooks states that many of the "lake dwellings" in Europe were destroyed not long after 1300 B. C., due to a great rise in the lakes. He states that in 1180 B. C. the Elanites migrated, which is only 29 years after the weather cycle peak of 1209 B. C. The Hoskos peoples conquered Egypt about the year 1800 B. C., which is only 42 years after the previous weather cycle peak of 1842 B. C. The Kassiterite migrations occurred about 2450 B. C., which is only 25 years after the previous weather cycle peak of 2475 B. C.

Britannica says that the Cinmerians were expelled from Phrygia somewhat before 585 B. C. It is therefore noteworthy that one of the peaks of the 633-year weather cycle was in 576 B. C. The next weather cycle peak of this series was in 57 A. D., and about 50 A. D. the Jafnite migrations from Yemen occurred.

When it is remembered that the dates of some of these migrations are not precisely known, and that for about 25 years before and after one of the "peaks" of the 633-year weather cycle the weather is greatly disturbed, it is seen that the above mentioned migrations are in excellent accord with the dates of the maxima of the 633-year cycle.

The writer has found four long cycles that have a striking relationship, namely that each is about twice the length of the next shorter one. Their approximate lengths are 81, 162, 316 and 633 years. Evidence is accumulating that there is a cycle almost exactly 8 times the last one named above. The first two cycles of this series of four cycles are due to Uranus and Neptune, each cycle being slightly shorter than the orbital period of the planets. The reason for the difference between the orbital period of a planet and the weather cycle that it causes seems to be this: The planet has an upper magnetic field in its atmosphere (like the Heaviside shell of electrons 75 miles or more above the earth) and the poles of this magnetic field rotate clockwise very slowly around the axial poles of the planet, whereas the planet travels counter-clockwise, which therefore causes this magnetic axis to point most nearly sunward and earthward oftener than once every revolution of the planet around the sun. Upon such occasions many storms occur on both sun and earth; the solar storms being the "sunspots."

The winter of 1323 was the coldest on record, and if it was caused by a planet whose cycle is 633 years, then we can look for very severe weather about 1956. For a generation before and after 1323, weather was greatly disturbed. The effect of the planet that probably causes the 633-year cycle is perhaps to be seen in the very unusual weather that has been recently experienced in many regions.

A Jupiter weather cycle of 11.2 years and a Uranus subcycle ($\frac{1}{4} \times 81.1 = 20.3$ years) have had "peaks" recently, and they have apparently been reinforced by the approaching cycle "peak" that will reach its apex about 1956.

Earthquakes and volcanic eruptions are always more numerous and more violent at times of the great weather "peaks," presumably because the same magnetic forces that affect the electrons in the air coincidently affect the electrons in the earth's molten interior. We need not be surprised, therefore, to hear of an unusual number of crustal disturbances, increasing intermittently, for the next 26 years.

In the following table the dates of the maxima or "peaks" of 6 important weather cycles are given, also the average length of each cycle. Names have been assigned to the two invisible planets that cause the two long cycles.

Planet	Cycle, Years	Date of a "Peak"
Jupiter	11.2	July, 1928
Saturn	28.1	December, 1925
Uranus	81.1	August, 1869
Neptune	161.6	January, 1837
Apollo	315.5	May, 1778
Janus	633	Winter of 1323

Each planet also causes weather subcycle peaks at intervals whose average length is one-twelfth of its cycle length, the semicycle "peaks" being usually the most pronounced of the subcycle "peaks."

It is scarcely to be wondered that meteorologists have found it very difficult to make reliable long-range forecasts, when there are at least 10 main weather cycles due to 10 planets, besides many subcycles of the main cycles. Without knowledge of the cause of weather cycles, even though the existence of such phenomena was more than suspected, and with but vague discernment of the length of only a few of the scores of cycles, it is not surprising that many meteorologists have questioned whether man ever can unravel the snarl called weather.

Cross Reference.—For discussion of an allied article entitled "The Synchronism of Planet Orbital Periods and Sunspot Cycles Due to the Planets," see March, 1930, issue of *Engineering and Contracting.*

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Filtration Engineer, Bureau of Engineering, Chicago, Ill.

Filter Bed Clogging

ONE of the problems that have baffled filter plant designers and operators from the very beginning of rapid sand filtration is the formation of clogged places in filter beds. These are areas of the sand bound together so firmly they are not broken up during washing. In the discussion of filter beds and cracks in filter beds, in the January and February, 1930, issues of Water Works and Sewerage, reference was made to temporary clogging in filter beds. This is clogging caused by coagulated matter penetrating into the beds, which is broken up and washed away each time the filter is washed.

In the present discussion we are considering clogging that is due to the sand being bound together so firmly it is not broken up by washing the filter. These clogged areas may vary in size from a few sand grains bound together to areas that extend from the gravel to the surface of the bed. The small clogged masses may be found distributed throughout the sand, but the larger ones rest on the gravel.

The size a particle has to be before it will settle to the bottom of the sand and will not be moved about by the washing varies with the specific gravity of the mass and the force of the wash water. So long as the clogged masses keep distributed throughout the sand bed they are of practically no significance in their effect on filtration, except that they may be breeding places for bacteria. It is when they form to such size as to settle to the bottom of the filter that they become of importance. No clogged area becomes of enormous size immediately, and very likely all large clogged areas have their start in clogged masess less than 1 in. in diameter.

The writer dicussed the formation of clogged areas in filter beds in 1924.* There have been no recent developments requiring a modification or change in what was presented at that time, but the subject is of such importance as to justify another and more thorough discussion; especially so as the data presented in 1924 did not impress the filtration profession to the extent that much improvement has been made. The leading filtration engineers are not now designing filter bed that remain any freer from clogging than the beds constructed years ago. The writer hopes that we are now near a solution of such troubles, but little has been done so far in filtration plants to prevent filter bed clogging. It requires an extended use of any device, or any change in operation to correctly judge its efficiency. The present article will be limited to discussing conditions that cause clogged areas to form, and a later article will deal more fully with means of preventing and breaking up such areas.

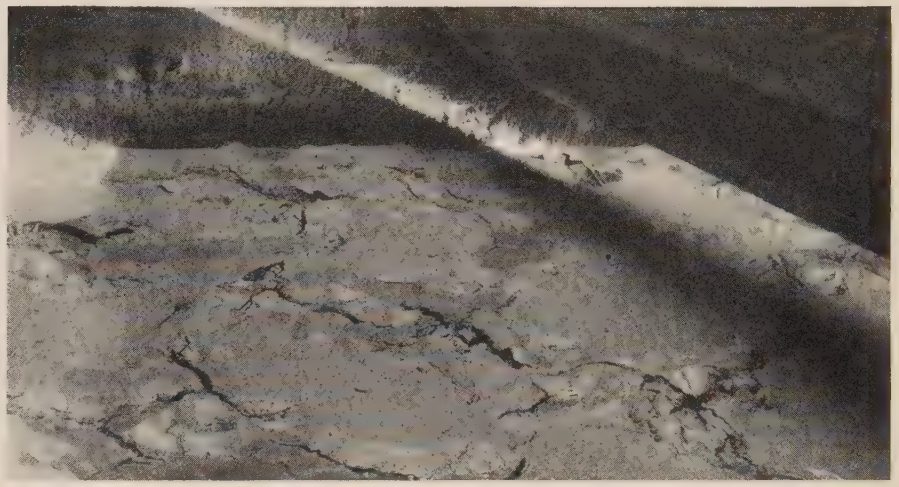


Fig. 1—Meshwork of Clogged Areas in Filter Bed

Filter plants throughout the country will be found varying all the way from beds that have no clogged areas to beds that become so badly clogged that fully one-half of the sand in the bed is bound together. Perhaps the design of the filter has some influence, but this is not the major factor. Two

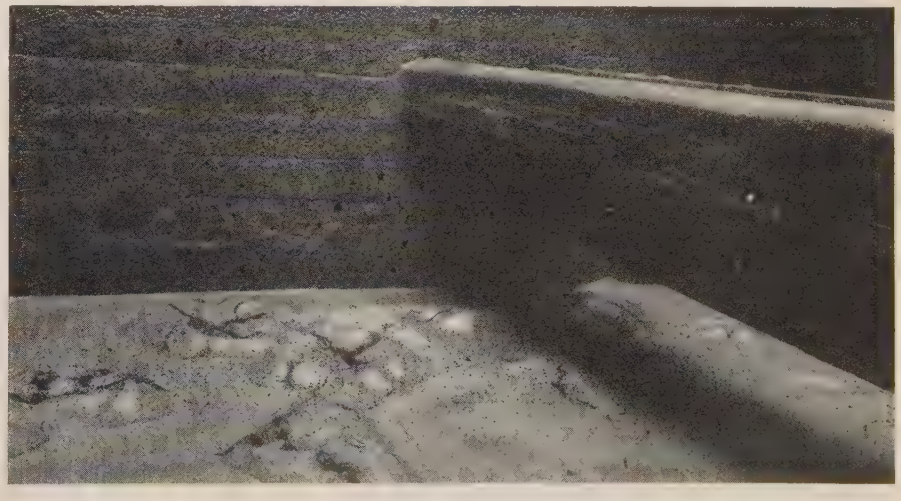


Fig. 2—Clogged Places Diminishing in Size

*Baylis, John R. Sand-Bed Studies at Montebello Filters, Baltimore. Eng. News-Record. 92: 13, 516-22, March 27, 1924.

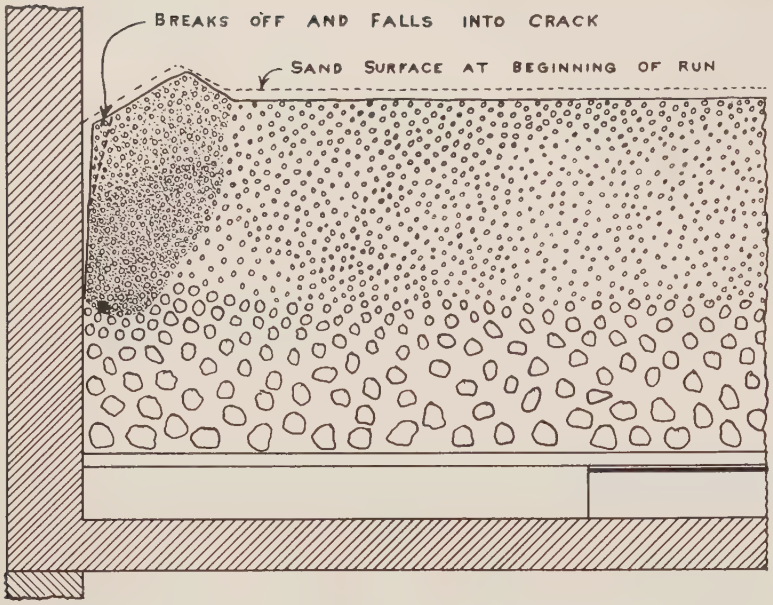


Fig. 3—Clogging Along the Sidewall

plants of the same design, with the same kind and size of sand in the filter beds, may vary greatly in their tendency to form clogged areas. The evidence is so strongly in favor of the character of the water being the major factor that this may be stated to be an established fact.

Cause of Clogging.—It is evident that the sand grains are held together by some adhesive substance. It also is evident that aluminum hydroxide or ferric hydroxide as ordinarily precipitated in coagulating water is not tough enough to furnish the adhesion necessary to bind the sand grains together unless there is some way in which much of the water could be squeezed out of the gelatinous precipitate. Even then these precipitates probably are not as adhesive as certain other materials. It is not believed that the binding material can be attributed to the coagulant alone, for if this was the case all filter beds would form clogged areas. It is likely that organic and possibly silicious jellies are more responsible than any other material. Some of the highly turbid waters may carry enough clay in suspension to be of aid in making a plastic precipitate; however, clogging is not confined to turbid waters. In fact it seems to be more pronounced where the water is not so turbid, though there are many exceptions to this statement.

Water that causes the formation of gelatinous coatings on the sand grains usually gives the most clogging trouble. This may be due partially to more adhesive material being present and partially to cracks in the bed. Sand with a gelatinous coating almost invariably settles during the run, causing cracks to open up along the sidewalls and frequently all over the surface. The cracks allow an accumulation of coagulated matter beneath the surface of the bed. When the wash water is first turned on, the sand begins to bulge in places, forcing the cracks together in other places. This may force together quite firmly the coagulated matter which has accumulated within the cracks and form clogged masses of sand and the tough material filtered out on the sides of the cracks. Such an assumption would be difficult to prove, but it seems probable. Cracks in filter beds are not necessarily forerunners of clogging, though they likely give considerable aid. When the clogged places begin to break up or diminish as the water gets colder in the late fall or winter, cracks in the surface of the filters may be more abundant than in the summer and early fall, when the tendency to clog is the greatest, so the cracks are not the main factor.

That there is a direct relation between the characteristics of the suspended matter in the water and the tendency to clog is evident from what takes place in many filtration plants. The writer has observed plants in which there will be serious clogging in the summer and fall months and practically no tendency to clog in the colder months. A bed in these plants in good condition at the beginning of winter usually remains in good condition until spring or summer. In fact most clogged places which form in the summer and fall will break up in the winter. The quickness with which clogged places will form when the tendency to clog is great is illustrated in Fig. 1. The filter was put in excellent condition by removing the sand and finer gravel, thoroughly washing, screening, and then returning the material to the filter. The procedure was to eject the sand from one bed to another with a Nichol's sand washing machine after the gravel had been put into good condition. The sand after washing was free from clogged masses and perfectly clean, with the exception of a very tough and hard coating composed largely of organic matter, silica, aluminum hydroxide, and manganese dioxide. This coating was so hard there was no tendency for the sand grains to adhere when pressed together.

When the bed was put back into service Nov. 7 it was in perfect condition. To be sure that biological growths on the sand grains themselves would not be a contributing factor, chlorine was added to the water prior to filtration to the extent that there was an excess of at least 0.3 parts per million residual after filtration. By Nov. 25, 18 days afterwards, there were many clogged places, as is shown by Fig. 1. All filters in the plant showed this same tendency to clog. About the first of December all the filters began to get in better shape, regardless of whether the water was or was not prechlorinated. Figure 2, taken Dec. 17, at the same point in the bed as Fig. 1, shows considerable clearing of the clogging.

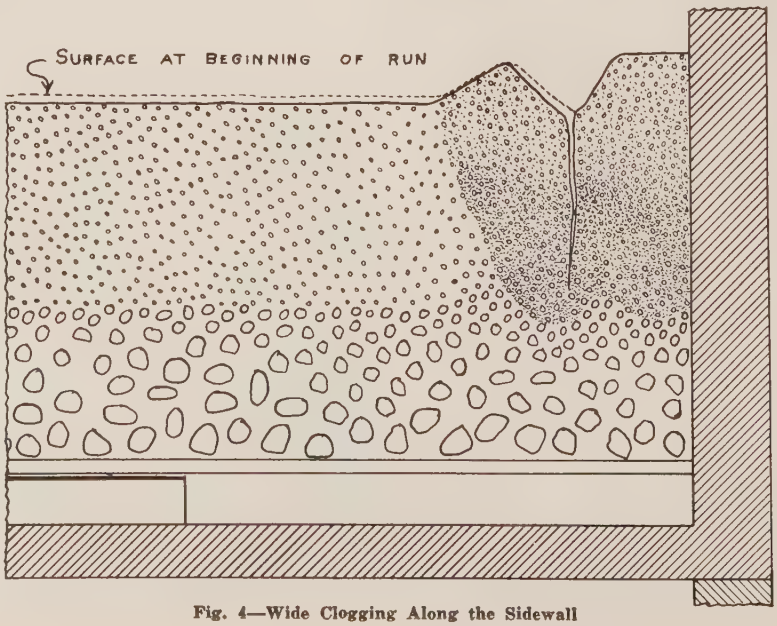


Fig. 4—Wide Clogging Along the Sidewall

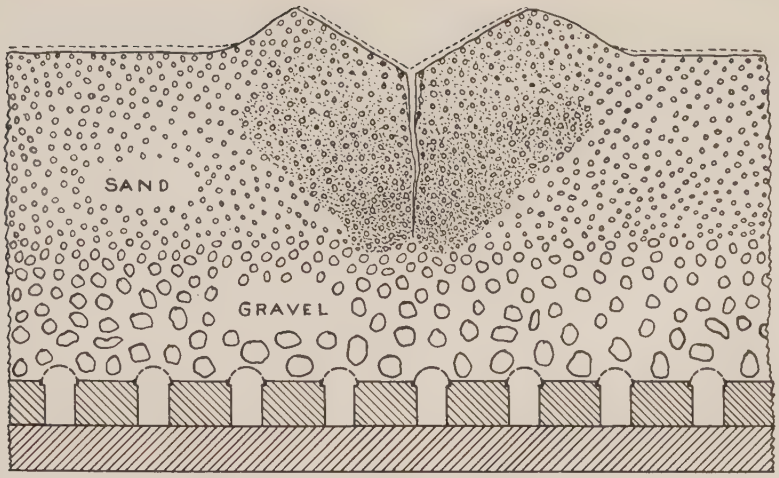


Fig. 5—Large Clogged Area in Filter Bed

By the first of January there was scarcely a clogged place that could be observed not only in this bed but in the others as well. All the beds remained in good condition, with the exception of a few clogged places along the sidewalls, until June or July, when the clogged places again appeared. This same procedure repeated itself year after year, but with the clogging not so extensive some of the years. Here we have water from the same source varying greatly in its tendency to cause clogging. These remarks should not be construed as meaning that the design, treatment of the water, and method of washing the filters have no influence. They do, but the major factor is the characteristics of the suspended matter, especially where standard practice has been followed in the design and in the operation of the filters.

The first visible evidence of clogging in a filter bed is slightly raised places in the sand surface, though it is evident that the clogged areas must be of considerable size to produce the raised places in the filter surface shown in Fig. 1 and 2. If a stone 6 in. in diameter was placed on top of the gravel in a sand bed 2 ft. deep there likely would be no visible evidence of the stone being present, but a stone 12 in. in diameter very likely would cause some unevenness of the surface. This is not to imply that it takes a clogged area 12 in. in diameter to become noticeable. The main factor is the nearness with which the clogged area extends to the surface. All clogged areas of any size must rest on the gravel, and unless they build up to considerable height there may be no evidence on the surface of their presence.

Clogging Along the Sidewalls.—There are very few filtration plants in which the filter beds do not form clogged places along the sidewalls, occasionally if not all the time. In many plants the sidewall clogging is all the clogging that takes place. Evidently this is the part of the filter having the greatest tendency to clog. Practically all filter beds are pushed away from the sidewalls as the loss of head increases. The cracks vary from ones that are almost negligible to cracks that may be 1½ in. wide at the top of the bed. This forms a filtering surface along the side of the bed where the crack has formed that acts as a filtering surface the same as the top surface of the bed. The accumulation of coagulated matter on this surface occurs to nearly the extent it does on the top surface. When the wash water is first turned on the sand is forced against the sidewall, pressing the coagulated matter firmly between the sand and the sidewall. If the coagulated matter contains adhesive matter it tends to stick both to the sidewall and the sand in direct contact with it. It adheres to the sidewall so firmly it is not removed by the washing. Also some of the sand remains firmly bound into the adhesive mass. When the crack opens up again on the next filter run the clogged masses, which at first are quite thin, may continue to adhere to the sidewall or they may pull away with the sand. Additional coagulated matter collects in the crack and the process is repeated. Each time the crack opens on the run and coagulated matter is deposited in it, additional material is added to the clogged masses.

Eventually the clogged masses become so large they drop to the gravel layer during washing. An accumulation of these clogged masses start clogged areas on the gravel surface, and the areas become larger and larger as additional clogged masses fall on top of the ones which have already settled to the bottom of the sand. The washing tends to break up some of them, but if they are forming at a rate faster than they are being broken up, soon a large clogged area is formed. This is usually against the sidewall. Deflection of the wash water by the clogged areas has a tendency to deposit an increasing number of clogged masses on top of the clogged area, building it higher and probably a little wider. Eventually the clogged area reaches a height near the top of the sand. Some of these sidewall clogged places become quite wide, as shown by the sketches in Fig. 3 and 4. The condition shown by Fig. 3 occurs in many filtration plants, even though no clogged places may form in the center of the beds.

After the clogged areas reach nearly to the surface they usually widen in a manner probably not so well understood by many filter operators. It is believed that they do not widen to any material extent by adhesive matter adhering to the side of the clogged area that is towards the sand not clogged. The clogging tends to restrict the area of the bed, and if the wash water continues to be applied at the same rate the velocity is increased in proportion to the area clogged, increasing the tendency of the wash water to wash away the clogged places. Almost invariably there is shrinkage of the sand beds during the runs in filters that have clogged places and, as was stated in the February issue of Water Works and Sewerage, cracks form along the sidewalls where there is shrinkage. In nearly all instances the crack is at first between the clogged place and the sidewall. This is illus-

Fig. 6—Badly Clogged Filter Bed

trated in Fig. 3. Sometimes when the clogged area builds up very wide it becomes so large it is difficult for the wash water to tilt it and it becomes fixed. Then the crack opens between the clogged mass and the sand not

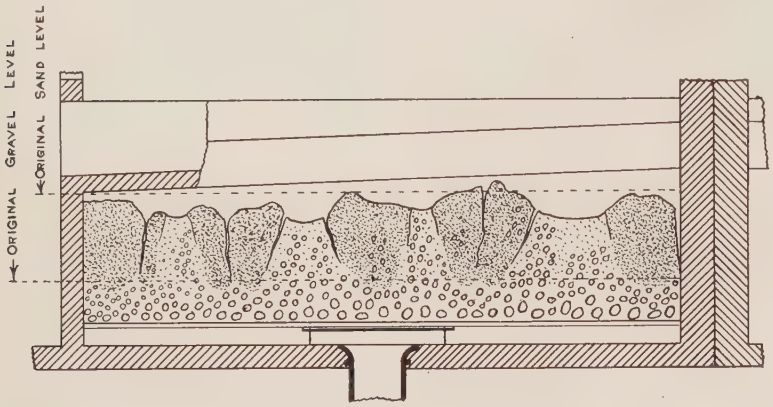


Fig. 7—Filter Bed Badly Clogged

clogged. Soon this builds up a clogged area by the side of old clogged area in the same manner as the clogged area was built up against the sidewall. This is shown in Fig. 4.

The writer will explain his interpretation of how clogged areas become wider. This is based on observation of many clogged places covering a period of several years. The clogged areas are held together so firmly they act as solids, except that a little water may gradually percolate through them. On each filter run the sidewalls crack open as the loss of head increases, tilting the clogged area. Each time the filter is washed the clogged area is tilted back against the sidewall. This compacts quite firmly any material getting into the lower part of the crack. So long as the filter is running there is enough side pressure to hold the sand together, but when it is cut off to be washed some of the sand near the top of the bed breaks loose and falls down into the crack. This is shown by the broken line in the upper left hand corner of the clogged area in Fig. 3. The sand dropping into the bottom part of the crack is mixed with coagulated material and the mixture is compacted quite firmly. It also is in a place where it is not disturbed by the wash water. If this material after compacting is ¼ in. in thickness, it is evident that the clogged area has been widened that much. There is the possibility that the clogged area is tilted the distance of the thickness of the compacted layer each time and that the process of widening is a gradual turning over of the clogged area.

It is believed to be more probable that the widening of the clogged area is by pushing the mass away in a nearly horizontal direction. When the wash water is turned on there is considerable force tending to lift the clogged places. With a washing rate of 15 gal. per square foot per minute the upward pressure is approximately 100 lb. per square foot for the average filter bed. This is not equal to the weight of the clogged area, but it probably is enough to so lessen the friction on the bottom as to allow it to be pushed away by the material being wedged between it and the wall near the bottom of the crack. Either tilting or being pushed away horizontally will explain the widening of the clogged areas. Perhaps they act in both ways in many instances. The significant fact is that the sidewall clogged areas do not build up on the side next to the sand which is not clogged, but on the side against the sidewall. Probably the only exception to this is the starting of a new clogged area against one that has grown so large it has become fixed and does not tilt on the filter runs. Then the widening is by building up between the two clogged areas.

Clogging in the Center of the Bed.—As previously stated, many filter beds do not form clogged places in the center of the bed; however, there are many that do. The center clogged places very likely have their origin somewhat similar to the places along the sidewalls, but they must depend on the clogged masses which form on or near the surface to accumulate and settle at points in quantities sufficient to start the clogged area. Why the clogged areas form in what may be termed a meshwork of areas is not definitely known. This formation is indicated very clearly in Fig. 1. The areas are not individual clogged places separated from each other, but they are joined together throughout the bed. It is true that the areas in Fig. 2 are separated from each other, but they are areas breaking up and diminishing in size. A number of photographs taken by the writer show the same characteristics as Fig. 1, except when the areas begin to break up in the winter months.

The writer is of the opinion that the washing causes this characteristic. If we examine a filter bed being washed when the water is coming off so clear the suspended sand may be observed, it will be found that the bed is a series of boils with the water and sand rushing upward in places and downward in other places. Very likely it is around these boils where the downward current strikes against the gravel that the small clogged masses are deposited and accumulate to the extent that they form clogged areas when the tendency to clog is great. The more highly a bed becomes clogged the more it gives characteristics of this phenomenon.

The center clogged places widen in a manner somewhat like those along the sidewalls. When the areas reach a height that they cause raised places in the surface, cracks form along one side of the clogged areas. Such cracks may be distinguished in Fig. 1 along the side of some of the narrower ridged places. One place is readily noticeable in the foreground near the center. The cracks act to widen the clogged areas in the same manner as the sidewall clogged areas are formed. In this case the clogged area already formed acts as the sidewall and another clogged area builds up on the opposite side of the crack. Figure 5 is sketch of a large center clogged place. It will be noted that the clogged places are split in two with a crack somewhere near the center. These characteristic clogged places with the crack near the center may be seen in the wider clogged places shown in Figs. 1 and 2. While

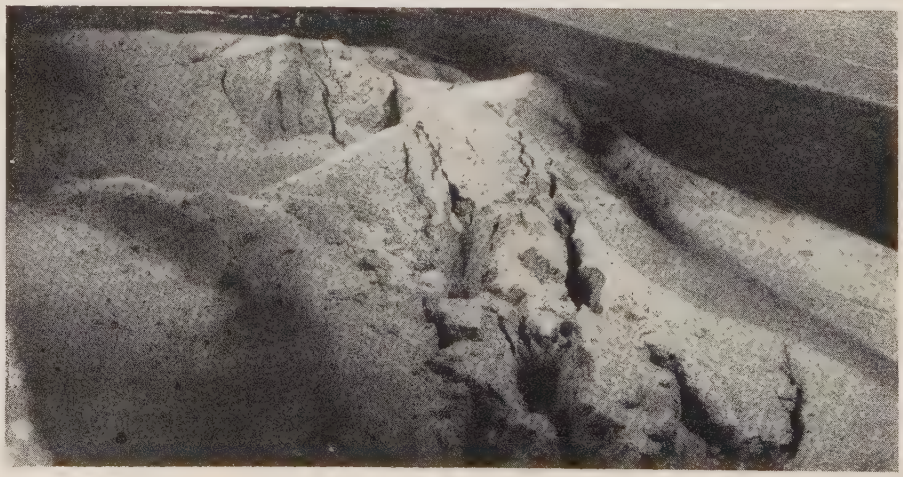


Fig. 8—Large Cracks Within Clogged Area

the clogged areas are diminishing in size in Fig. 2, they continue to build up from the center. They are being washed away on the outside, however, faster than they are being built up from the center. Material removed from the water by filtration and some of the sand fall into the bottom of the cracks when they open on the run the same as it does along the sidewall, especially when the filter is cut off to be washed. When the filter is washed this material is compacted by being wedged in the crack just as it is in the sidewall cracks. In this case it is mashed together between two clogged areas. The compacted material adds to the clogged mass and forces the clogged masses apart; that is, the clogged areas are built wider from the center, or from the crack wherever it happens to be.

Figures 6 and 7 show how badly a bed may become clogged. The photograph in Fig. 6 shows the sand excavated to the original gravel layer in one place, which is indicated by the X mark. The arrow points to gravel within a few inches of the surface. Over one-half of the area of the bed was clogged and some of the sand had been lost by being washed through the disturbed gravel. A washing rate of approximately 15 gal. per square foot per minute had been maintained notwithstanding such a large portion of the bed being clogged, and this made the rate through the portion not clogged great enough to disturb the gravel. The sketch in Fig. 7 was from a section dug across the bed so the clogged places could be measured. It is typical of the entire bed. There is side clogging so wide on the left side of the sketch that the area has become fixed and the crack was then opening at a point about 16 to 18 in. from the wall. The sketch shows center clogged places with cracks in the center similar to the sketch in Fig. 5, and others so large they have become fixed and cracks are opening between the clogged areas and the portion not clogged.

Much that the writer has described represents extreme conditions, but it is such conditions that give the best proof of the causes for the formation of clogged areas. Everything is taken from actual conditions in a well designed and well operated filtration plant. To many who are not troubled with excessive clogging it may seem almost impossible for beds to get in such conditions, but this is what a few filter operators have to contend with in trying to operate their plants efficiently. The manganese bearing waters probably are the worst to cause filter bed clogging, but manganese is not the entire cause. Any water that produces a soft coating on the sand grains which causes the beds to settle during the run usually gives such troubles. Fortunately the coated sand appears to be more effective in removing the suspended matter from the water and even though cracks may open almost to the gravel, very little coagulated matter passes the filters. If the washing is such that the gravel is not disturbed the badly clogged beds in localities where the water temperature goes nearly to the freezing point in winter will clear themselves of most of the clogged areas, except possibly along the sidewalls.

Some are of the opinion that coarse sand of certain kinds will prevent clogging. Figure 8 shows the condition of a filter bed having sand of approximately 0.6 mm. for the 10 per cent size. This bed was constructed in accordance with what was thought to be ideal for resisting clogging, but the photograph shows that the ideal bed clogged almost as badly as those with finer sand. All of this shows there is no hope of constructing filter beds which are washed in accordance with present practice that will not form clogged places in some waters. The cause of clogging in most instances is not the design of the filters, the size and kind of sand, nor the way in which the filters are washed, but the character of water being filtered. Clogging can be remedied for such waters only by some change in the design of the filters or methods of operation especially adapted for preventing the formation of clogged areas.

Romance in Sewage Disposal

An Editorial in January Sewage Works Journal

The romantic or emotional aspects of science have in general been emphasized to a greater extent in France than in England or America. The Englishman or American in technical or scientific work is more or less prosaic and characterized primarily by curiosity or inquisitiveness rather than by lofty thoughts of his contributions to culture or humanity.

Notwithstanding this characteristic, we occasionally find writers who attempt to cast glamour over the unadorned facts of garbage disposal, sewage treatment and sludge disposal. Some of these bedtime stories are entertaining as witness the following editorial from a recent issue of The Surveyor: "The Salubrious Dump: Its Flora and Fauna."

"In an article entitled 'The Botany of Refuse' the Times deals with 'these huge, evil-smelling piles' which the metropolis has in unneighborly manner inflicted upon Home Counties' residents. But it treats the subject from an entirely new standpoint—that of the botanist, 'who finds the rubbish heaps of a great city a perennial source of interest.' The reference is particularly to the tangle of vegetation which covers the refuse within a few months of its being tipped, and it is interesting to hear that 'most of the plants in the tangle are of foreign origin, and one may find among them species from every quarter of the globe.' A list of foreign plants found in such places round London contains no fewer than 250 species, but we personally prefer to do our own botanizing on the swards and among the hedgerows of country lanes. We are content to leave the botanist in full possession of his 'sneaking affection for these dumps,' and to ally ourselves with the party to whom they cause 'such natural offense.'

"Some years ago a gentleman whose sanitary enthusiasm outran his sense of the ridiculous, wrote an article which he called 'The Romance of Sewage Disposal,' in which he pictured the dead little microbes marrying and giving in marriage, and within the precincts of their unsavory habitat multiplying by millions and thriving upon a diet of very mixed salubrity. It was just the mental pabulum for the popular weeklies which dabbed in the wonders of science among other things, and we believe that the author was commissioned to write many articles in similar vein. Regarded in the right light, there is a certain spice of romance in everything, although much depends upon the actual interpretation of the word. There may be some hidden romance in the dumps (there is at least beauty in their vegetation) but it has yet to be discovered. Meanwhile we would suggest to the gentleman who penned the Times article that he should turn his attention to the fauna of the dumps. Local color could be acquired by the simple expedient of a night spent upon them. One would be enough."

The fauna of sludge dumps was discussed at the New York meeting, as reported in this issue; a fly paper comes from California; odors have been wafted from Schenectady and Plainfield. These discussions are hardly romantic, but nevertheless such problems are familiar to most of us, and their solution usually demands true scientific research and mature engineering judgment.

Whether or not we are able to find romance in our work, the fact remains that the work must be done and we are able to find satisfaction in some of its aspects. Possibly our philosophy may best be expresed in the words of the drain man, Robert Smith, in Charles Rann Kennedy's "The Servant in the House":

"That's what I come 'ere to talk abaht—my job. P'r'aps you'll think as it ain't a tasty subjic, before a lot o' nice, clean, respectable people as never 'ad anythin' worse on their fingers than a bit o' lawn dirt, playin' crokey; but some one 'as to see to the drains, some one 'as to clear up the muck of the world; I'm the one' an' I'm 'ere to tell you abaht it."

Activated Sludge Process for Columbus, O.

Two Plans Submitted for Preventing Pollution of Scioto River

DURING the past year studies have been made under the direction of Robert A. Allton, Sewage Disposal Engineer of the Division of Engineering and Construction of Columbus, O., and John H. Gregory, Consulting Engineer, to determine the proper method for the final treatment of sewage for the city of Columbus. Estimates were submitted to R. H. Simpson, Chief Engineer of the Division, and were filed by him on Feb. 3 with the city council. The following is extracted from the report.

Statement of Problem.—To satisfactorily correct the pollution of the Scioto River and Alum Creek, due to the discharge of sewage into them by the city of Columbus, the sewage from the city must be so treated that the water in these streams will, at no time, be devoid of dissolved oxygen and so that sewage solids entering these streams will be reduced to a minimum and will not cause a nuisance.

To purify sewage, oxygen is needed. The amount of oxygen, so needed, for a given volume and strength of sewage is known as the oxygen demand of the sewage. The oxygen required to meet this oxygen demand is supplied partly by the oxygen dissolved in the water of the stream receiving the sewage and partly by some method of sewage treatment. In 1945 it is estimated that the sewage flow from the city of Columbus will have a one-day oxygen demand of about 38,500 lb. of oxygen per day and, that during periods of low flow, the water in the Scioto River can furnish only about 6,500 lb. of oxygen per day. The difference between the oxygen demand of the sewage and the oxygen supply of the river represents the quantity of oxygen which the sewage treatment works must furnish, or, stating it in another way, this difference represents the reduction in oxygen demand of the sewage which the treatment works must accamplish.

The removal of the suspended solids in the sewage by the sewage treatment works must be sufficient in amount to prevent the formation of sludge beds or scum patches in the river.

Design Date.—Experience has shown that it is economical and wise to design a sewage treatment works for conditions which will obtain, in general, from 12 to 15 years after the works are finished and placed in operation. This is not only desirable from the standpoint of cost, but has the added advantage of allowing the works to operate under a lighter load during the first years of operation and of giving a reasonably long period of operation uninterrupted by the construction of additions to the works. For Columbus conditions, the year 1945 has been selected as the design date.

Bases of Design.—The bases of design may be briefly summarized as follows:

1. The sewage treatment works are to be designed to meet the estimated conditions in 1945, with provisions for expansion to meet the estimated conditions in 1960.

2. The estimated population in the area tributary to the sewage treatment works in 1945 is 485,000.

3. The estimated average dry weather sewage flow in 1945 is 60 million gallons per day.

4. The sewage treatment works must be designed to reduce the oxygen demand of the raw sewage and to remove the suspended solids to such a degree that the discharge of the treated sewage into the river will not cause a nuisance.

5. The average treatment works shall be capable of treating a flow during storms of 200 per cent of the average dry weather flow.

Proposed Sewage Treatment Works.—Several different sewage treatment projects have been carefully studied and of these the two most desirable are briefly described below. Both of these projects are designed to treat the estimated 1945 sewage flow and to produce the results required to prevent nuisance in the river.

Project I: This project contemplates the use of the existing sewage treatment works, with modifications, for the complete treatment of a portion of the sewage flow, and the construction of additional works of the activated sludge type, at the site of the existing sewage treatment works, for complete treatment of the balance of the sewage flow.

Under this project no additional land will have to be acquired by the city and the existing works will be utilized as fully as possibly.

Project II: This project contemplates the abandonment of the existing sewage treatment works, and the construction of an entirely new sewage treatment works of the activated sludge type, at a new site farther down stream on the Scioto River, for complete treatment of the entire sewage flow.

Under this project the city will have to buy a tract of land some miles south of the present sewage treatment works and will also have to acquire a right-of-way for force-mains from the site of the existing works to the new site.

Estimates of Cost.—The estimated cost of construction of Project I, utilizing the existing sewage treatment works, is $4,000,000.

The estimated cost of construction of Project II, involving the abandonment of the existing works and the construction of an entirely new works down stream, is $6,100,000.

The estimated total annual cost of the treatment of the sewage under Project 1, including maintenance, operation and fixed charges, as of 1935, is $524,000 or $1.39 per capita per year, decreasing in 1945 to $481,000 or 99 ct. per capita per year.

The estimated total annual cost of the treatment of the sewage under Project II, including maintenance, operation and fixed charges, as of 1935, is $739,100 or $1.95 per capita per year, decreasing in 1945 to $658,700 or $1.36 per capita per year.

The above estimates of cost of construction and annual costs are summarized in the tables hereto appended.

In presenting these estimates of cost it should be stated that they are preliminary and may be subject to revision when detail contract plans have been completed.

Project I—Sewage Treatment Works—Involving the Utilization of the Existing Works

Table 1—Estimated Cost of Construction

Additional force main and connections	$ 242,000
Primary settling tanks and equipment	347,000
Sludge digestion tanks and equipment	814,000
Sludge drying beds and equipment	219,000
Activated sludge plant and equipment	1,822,000
Modification of trickling filters	182,000
Trickling filter settling tanks	86,000
Buildings, laboratory and equipment	72,000
New levee and moving existing levee	107,000
Grading, roads, drains, water mains, lighting, etc	109,000
Total estimated cost of construction	$4,000,000

Table 2—Estimated Annual Cost, Including Maintenance, Operation and Fixed Charges

Item	Total	Cost per Capita
1935—		
Fixed charges	$340,000	$0.90
Maintenance and operation	184,000	.49
Total	$524,000	$1.39
1945—		
Fixed charges	$268,000	$0.55
Maintenance and operation	213,000	.44
Total	$481,000	$0.99

Project II—Sewage Treatment Works—Involving the Abandonment of the Existing Works

Table 3—Estimated Cost of Construction

Additional force main and connections	$1,756,000
Primary settling tanks and equipment	347,000
Sludge digestion tanks and equipment	1,031,000
Sludge drying beds and equipment	256,000
Activated sludge plant and equipment	2,430,000
Buildings, laboratory and equipment	72,000
Grading, roads, drains, water supply, lighting, etc	128.000
Land	80.000
Total estimated cost of construction	$6,100,000

Table 4—Estimated Annual Cost—Including Maintenance, Operation and Fixed Charges

Item	Total	Cost per Capita
1935—		
Fixed charges	$518,500	$1.37
Maintenance and operation	220,600	.58
Total	$739,100	$1.95
1945—		
Fixed charges	$408,700	$0.84
Maintenance and operation	250,000	.52
Total	$658,700	$1.36

Instructions for Filter Attendants

Rules and Regulations for the Guidance of the Employees at the Montebello Filters of the City of Baltimore, Md.

By JAMES W. ARMSTRONG
Filtration Engineer, City Water Department, Baltimore, Md.

With the semi-skilled labor usually employed for operators or attendants in filtration plants, it is necessary to have specific instructions as to the work each employee should do and to insist on a rigid observance of the instructions. To outline the duties of the various employees is not a simple task.

Some 12 or 13 years ago, Mr. Armstrong got up instructions for the operators at the Montebello Filters. The instructions have been changed from time to time to make them cover more specifically the work to be done. Paragraphs that were useless or could not be complied with were cut out and new paragraphs added where it was seen that the instructions did not fully cover the duties. The instructions as now written constitute a very concise and specific outline of the duties of the various employees. There is no need of having instructions to tell the operators how to enter records on the operating sheets furnished them, for they know that this must be done.

These instructions are for the operators of the Montebello Filters and are not applicable without change to other plants, but they serve as a model for those who may wish to get up similar instructions. The writer was associated with Mr. Armstrong at the Montebello Filters for 10 years and during that time had much to do with the enforcement of the instructions. They are practical, and leave very little room for argument as to whose duty it is to perform certain work.—John R. Baylis, Associate Editor.

Instructions for Controller Attendants

Chemical Feed Controllers.—1. Chemical feed controllers shall be used alternately for a period of one month.

2. After throwing a controller out of service, it shall be thoroughly cleaned and put in readiness for future use. Flush the tank and nozzle with clean water, but do not take the nozzle apart.

3. It shall be the duty of the attendant retiring from duty on the second watch to make the necessary changes and clean the controllers thrown out of service.

4. Stir the sludge in both lime and alum controller feed tanks at frequent intervals. This is particularly important in the lime tanks.

5. In changing the controller rate of discharge, always turn the pointer past the desired point of setting toward the zero mark, and make the final adjustment by turning the pointer away from the zero mark. Failure to observe this will result in inaccuracy of discharge.

6. At least once each watch, flush the nozzle of the controller in service by opening it wide, and immediately afterward adjusting to the required opening.

7. Always disconnect all nozzles not in service and lower them carefully to rest. The nozzles are expensive and failure to lower them carefully may result in breaking them. Remove the weight from the lower lever arm of all chemical feed controllers not in service.

8. Keep an eye on the small bronze cables that actuate the nozzles. They should be taut at all times. A slack cable means that something has gone wrong.

9. See that the sliding clamp at the pinch valve is kept clean and greased at all times.

Application of Lime.—10. The application of lime shall be controlled entirely by the pH machine, so that a value of 8.2 shall, as nearly as possible, be maintained in the water leaving the plant. In event of trouble with the pH machine, the filter attendant will make pH determinations by the color method and report to the controller attendant.

11. The pH machine should be examined every half hour to see that the correct amount of lime is going into the water.

Application of Alum.—12. The rate at which alum is applied to the water will at all times be determined by the chemist. Should the water be insufficiently coagulated at a time when the chemist is not on duty, increase the dose slightly and immediately notify him if he can be reached by telephone.

Equalizing Alum Solution.—13. In filling the solution tanks in the old plant, a depth of 3.75 ft. of 10 per cent solution should be admitted from the boiling tank. It should then be immediately diluted to a depth of 15 ft. in order to prepare a 2½ per cent solution for supplying the feed controllers.

14. Before withdrawing solution from the boiling tanks at the new plant, be sure that the solution is thoroughly agitated, but before opening the valves for its withdrawal, be sure that the air is cut off. Failure to do this will result in excessive corrosion of pipes.

15. After the requisite amount of 10 per cent solution has passed over to the old plant, always open the flushing valve wide and leave it open for a period of from 15 to 20 minutes, in order to entirely clear the 4-in. pipe line of all alum solution.

Agitation of Chemical Solutions.—16. Use only sufficient air to give the alum solution a slight agitation.

17. If no alum is being made or solution fed from the new plant, stop the air compressors.

18. Start the lime agitators about an hour, and the alum agitators about 15 minutes before tapping a new tank. Let the agitators run continuously as long as chemicals are being withdrawn. This is especially important with the lime.

Log Book.—19. Note in the log book the time of tapping and emptying of each tank. If for any reason the strength varies from 2½ per cent, or the depth varies from the 15 ft. in the old plant, or the established depth in the new plant, make a special note stating the facts.

Float Tubes.—20. The float tubes for actuating the chemical recording gauges are designed for operation with clean water, and it is very important that the chemicals be kept out of these tubes and the piping connecting the float tubes with the solution tanks.

21. In order to prevent the solution from entering the float tubes, the small valve connecting the tank with the tubes should be closed during the time of mixing solution, and the valve opened, admitting pressure water into the small piping. When the tank is ready to be thrown in service, the pressure valve should be closed and the other valve opened.

Gauges and Charts.—22. The charts of the daily recording gauges should be changed as near midnight as possible.

23. Always observe carefully the time and see that the chart is started correctly.

24. Use as much care as possible in placing charts to see that the ink is not spilled from the pens. Be careful not to pull the pen arm back too far, as to do so may injure the instrument and impair its accuracy.

25. Simplex Valve & Meter charts should have their bottom edges coincide exactly with the bottom of the cylinders.

26. In interpreting the meter charts and the filtered water level gauge, an allowance of about 20 minutes should be made at the time of changing rates for the lag in the movement of the pen due to the large float tubes.

Clock Winding.—27. Wind all clocks each Monday and Thursday.

Samples.—28. Samples of water from the entrance to the coagulating basins shall be put in the large beakers once each hour on the hour.

29. Raw water samples shall be taken once each watch. If the water is bad they shall be taken each hour.

30. Every two hours, approximately on the even hours, a sample shall be taken from coagulating basins Nos. 1 and 3, and the filtered water conduit of the new plant and put in the large composite sample bottles.

31. A bacterial sample of the combined filter effluent shall be taken from the filtered water conduit of the new plant at 2 A. M. and 8 P. M.

Elevator.—32. Do not use the elevators for passenger service, except when it is necessary to go to the top floor of the tower.

33. Always start and stop the elevator by means of the rope. Never by the little switch.

34. Never suddenly reverse the direction of the elevator; always come to a full stop before changing the direction.

35. Always close the safety gate and shut the outer doors before starting and upon leaving the elevator.

Valves.—36. Open and close all valves gradually, especially those on the pressure system. Suddenly stopping the flow of water in a pipe results in water hammer. Water hammer causes leaky joints and trouble with valves.

37. Do not use wrenches for closing valves. Much injury has been done to valves by improper handling. If a valve cannot be closed properly by hand, without forcing, report it as being out of order.

38. When difficulty is encountered in closing valves due to the accumulation of grit or sludge in the bottom of the body, the seat can often be freed from obstructions by moving the discs slowly up and down a few times before closing. In case of the 12-in. lime valves, the seats can be inspected.

Liquid Chlorine.—39. Never change the percentage of liquid chlorine from the amount shown in the table without orders from the chemist.

40. Every two hours, on the even hour, a record should be made in the chlorine book of the weight of chlorine on the scales and the rate of application. The midnight reading should be taken immediately after changing the Venturi meter chart, so that the correct amount used for the calendar day can be computed.

41. As nearly as possible, on the hour of every odd hour, the Venturi meter should be examined to see whether the rate of flow has changed sufficiently to warrant any change in the application of chlorine.

42. Whenever the rate of flow changes, the proper change should be made in the amount of liquid chlorine added to the water, and the weight should be recorded so that the performance of the apparatus can be checked.

43. When new cylinders are added, be sure and record the total weight immediately before and after placing.

44. Never turn on more cylinders than enough to keep the pressure up to the required amount. In opening cylinders begin on the left hand side when facing the scales, and open them in succession toward the right, one or two at a time as they may be needed.

45. Should trouble be experienced in maintaining the required rate of flow from the chlorine apparatus, make sure that all cylinders are turned on and the proper valves are all open. If in cold weather, be sure that the room is at the proper temperature. If these remedies fail, notify the chemist at once.

46. Keep the temperature of the cylinder room above 70° F. and the hand on the pressure valve as near 25 lb. as possible.

47. Whenever the smell of chlorine is detected, a careful test should be made at once to determine the source. Should a leak occur in a joint, the joint should be immediately tightened. Should a leak require the attention of a mechanic, cut out if possible, the defective apparatus and notify the mechanic at once.

48. Keep the doors to the chlorine room shut at all times, and the windows in the cylinder room shut.

Manhole Covers.—49. Always replace manhole covers and spout hole covers as soon as the requirements of service permit. Never leave any manholes open, especially in the tower.

Lights.—50. Use all the lights necessary for doing your work properly, but do not burn useless light. Turn out all lights when through with them, except the few required for general illumination.

In General.—51. The retiring attendant shall inform the one reporting for duty of anything requiring his attention.

52. The reporting attendant, upon taking charge of a watch, shall examine all gauges and apparatus of which he has charge, in order to assure himself that everything is working satisfactorily.

53. Should any of the gauges, valves, or other apparatus become out of order, do not attempt to repair them, except in the case of minor troubles such as slipping of cables from the pulleys, the tightening of nuts, etc. Make a record in duplicate of repairs requiring the services of a mechanic, on the slips provided for the purpose.

54. In case of an accident requiring immediately attention, notify the mechanic and afterwards make the report.

55. It shall be the duty of the operator on the second watch to keep the pens clean and in good operating condition.

INSTRUCTIONS FOR FILTER ATTENDANTS

First Consideration.—1. The first consideration in operating the filters is to see that sufficient water is delivered to the city at all times, and the second is to see that the quality of the water is the best that can be delivered. With both of these factors the filter attendant has much to do.

Control of Water.—The quantity of water delivered, of course, depends upon the amount being used by the city. In order to be prepared to meet the city's need in the safest way, the water level in the filtered water reservoir should be kept as high as possible at all times. To do this, the filters should be kept clean and capable of delivering their maximum output, and the pumping rate should be kept closely to the filtering rate. While it is not practicable to do this exactly, for the reason that an economical pumping combination does not always coincide with the filter requirements; the filter attendant should carefully study the different pump combinations with the object of securing the best operating results. The pumping station operators can give the most economical pump combinations for securing different rates of flow. The skill of the attendant in achieving the above results can be judged in a large measure by the regularity and evenness of the lines on the Venturi meters and filtered water level charts. The plant should be operated so as to prevent high peak loads.

Water Level.—3. Filter attendants should endeavor to keep the water level of the filters at least 4 in. below their top, and if possible, never let it drop more than 4 in. below the bottom of the walks. In order to secure the most economical rate of pumping, it may be at times necessary to let the water drop somewhat below the level stated above, but it should be brought back to the proper level as soon as possible.

Improper Coagulation.—4. Improper coagulation is sure to give inferior results, and while the attendant is not responsible for the application of chemicals, he should be the first one to discover any deficient coagulation. By immediately reporting to the chemist the slightest appearance of insufficient treatment, the filter attendant may be a great help in maintaining a high plant efficiency. If the chemist is not on duty, report improper treatment of the water to the controller attendant.

On Washing Filters.—5. It is not possible to give specific instructions for washing filters that will apply at all times. The quality of the filter effluent, and the rate of flow, are the only factors to be used in determining whether or not a filter needs washing.

Sight Glasses.—6. The sight glasses should be used for determining the time for washing a filter. If the water in the glass appears slightly turbid, it is evidence that the filter needs washing.

Rate of Flow.—7. If the rate of flow from any filter drops much below that of the other filters, due to clogging of the sand surface, it should be washed, regardless of the quality of the effluent. Reduced rate of flow may be caused by long filter runs, high turbidities, the presence of large numbers of organisms or organic matter in the water.

Loss of Head.—8. The loss of head curve should not of itself be used as a washing but as the loss of head increases, it should be used as a signal for examining the sight glass.

Length of Runs.—9. The length of filter runs will vary greatly from time to time, and should never be used as an index for washing. In case of an unusually long run, the chemist's attention should be called to the fact.

Order of Opening Valves.—10. Before starting to wash, the influent valve should be closed and water should be allowed to filter down to within a few inches of the sand level. Then the butterfly and effluent valves should be closed, afterwards the 30 in. drain valve should be opened and then the 24 in. wash water valve should be opened.

Filters Out of Service.—11. Plan the washing of filters so that no more than two filters will be cut out of service at the same time.

Draining Below Sand Surface.—12. Do not drain the filters below the sand level. If for any reason the water in any filter drains down below the sand level, air will be drawn into the sand bed and when the wash water is applied, a thick tough foam will be formed to which considerable sand adheres that will be carried away with the wash water.

Operating Wash Water Valve.—13. In opening the wash water valve, it should be done very gradually until the top layer of sand has been thoroughly broken, then the valve should be opened the full distance to secure the necessary rate of wash. Should air bubbles escape from the sand, special care should be taken to admit wash water slowly. Failure to observe these precautions may result in a "blow out" of the filter bed.

After Washing.—14. Immediately after washing, the filter should again be put into service. The 24 in. influent valve should only be opened a distance of about 6 in. until the filter tank is full, when it should be opened wide. Failure to follow this precaution will cause ridging of the sand.

After the water has reached the normal level, the effluent valve should be opened about 6 in. and the filter should be allowed to operate for about one hour; afterward, it should be opened wide. It is important to start filtering at a slow rate.

Duration of Wash.—15. The duration of wash shall be determined by the turbidity of the waste water entering the troughs. Do not wash until the water flows entirely clear; a slight turbidity at the close of the waste is desirable. The time of wash to be recorded shall be taken from the instant the water overflows the gutters, until the operating lever controlling the wash water valve is reversed.

On Putting New Filters Into Service.—16. If for any reason the water should be drained from beneath a filter, do not fill it by admitting water through the influent valve, but fill it by admitting water slowly through the wash water valve. When the air has been driven from the sand bed, water should be admitted in the usual way.

During the Wash.—17. The filter attendant should spend the best part of the washing period walking over the filter observing effects of the wash, and he should not leave the filter being washed until the influent valve is opened and the filter is again ready for service.

Boosting.—18. Boosting of a filter should never be resorted to unless by special instruction.

Wash Water Pump.—19. Only run one wash water pump at a time.

Wash Water Tanks.—20. Keep the wash water tanks full and ready for service. Do not empty the wash water tanks unless by special instruction.

In General.—21. The retiring operator shall inform the one reporting for duty anything requiring his special attention.

22. The reporting attendant shall examine all charts, see that they are registering correctly, and note any filters that need washing.

23. Any irregularities in the performance of the filters should be reported at once to the chemist.

26. The Venturi meter chart must be changed promptly at midnight, and the other charts as near that hour as possible. Note any variation from the correct time or irregularities in operation on the charts removed. In placing charts be sure that they are set at the correct time, and that there is no lost motion on the dial. The Simplex meter charts should have their bottom edges coincide exactly with the bottom of the cylinder.

27. Before placing the rate of flow-loss of head charts in the new filter plant, see that the pens are properly adjusted; that the loss of head pen is not slightly above and the rate of flow pen slightly below the scratch on the dial. Failure to do this may result in injury to the instrument.

28. It shall be the duty of the attendant on the second watch to keep the pens clean and in good operating condition.

29. If a sight glass loses its water, it shall be the duty of the filter attendant to immediately refill it with water and start the siphon.

30. Whenever the pressure drops below the amount necessary to open the hydraulic valves, the attendant shall start the booster pump and run it so long as it may be required for washing.

31. It shall be the duty of the filter attendants to keep the operating tables and sight glasses in a spotlessly clean condition. They shall also keep the floors clean, and the mud and algae growths removed from the wash water troughs and sides of the filters. A little furniture polish should be used occasionally on the wooden doors, but no furniture polish or oil should be used on the marble.

32. Samples shall be tested for pH every hour.

Samples shall be tested for residual chlorine every two hours.

Work of Wisconsin Sanitary Bureau in 1929

The State Bureau of Sanitary Engineering made 667 investigations in Wisconsin during 1929, 88 more than the preceding year, according to the report of the bureau to the State Board of Health.

Industrial waste investigations increased from 179 in 1928 to 246 in 1929. Stream surveys were made along the lower Fox, Wisconsin, Flambeau, Oconto, Peshtigo and Menomonee rivers through the co-operation of the chemists of paper mills. Further surveys of the Rock, Crawfish, Fox (Illinois tributary), upper Milwaukee, Sheboyagan, Fond du Lac and Wolf rivers will be made.

A comprehensive survey of waste conditions in virtually all pulp and paper mills was completed.

Since the treatment and satisfactory disposal of milk plant wastes constitute a major problem in Wisconsin, a careful investigation of five methods of treatment has been conducted by the bureau at De Forest, Wis. These studies and observations, the report said, show the feasability of efficient and economical treatment of milk plant wastes by means of a type of filtration system, plans for which have been prepared by the department for use of operators.

During the year plans for municipal incinerators for garbage disposal were approved for Racine, Oshkosh and Whitefish Bay. Plans for a swimming pool for Black River Falls were also approved.

The Iron Removal Plant at Albuquerque, New Mexico

Unusual Water Problems Being Handled Very Satisfactorily in the New Plant

By F. M. VEACH

With Black & Veatch, Consulting Engineers, Kansas City, Mo.

THE treatment plant, which has been operating a little over a year, includes two mixing basins of the tangential flow type, in which the necessary agitation is afforded by the motion of the water itself, two settling basins, two filter units of the gravity type and chemical feeding equipment for lime, alum and chlorine.

The capacities of the various units, based on a normal flow of 5,000,000 gal. per day are as follows:

Mixing basins, 10 minutes each.

Settling basins, 1.5 hours.

Filters, 874 sq. ft. of filter surface, with control piping and valves arranged for operation at a rate of 4 gal. per square foot per minute, or approximately double the conventional filtration rate.

Clear water storage. Only 200,000 gal. are provided at the plant since the city has 13 million gallons of storage in high lever reservoirs.

The principal chemical treatment consists of the use of lime for the removal of carbon dioxide and iron as well as for partial softening, but a small amount of alum is used, as an aid to filtration.

Chlorine is not regularly used since numerous bacteriological tests have shown it unnecessary. Equipment for chlorination is set up in the plant and a supply of chlorine is kept on hand for emergency use.

Iron Removal with Lime.—A departure from the usual method of using aeration for carbon dioxide removal has been adopted here, since it was found that the additional lime required for this purpose is less expensive than the additional pumping head required for the operation of an aerator.

In routine operation lime is fed by means of a dry feed machine, into one of the mixing basins. After mixing, the water flows to the settling basins when the greater part of the iron is precipitated. From the settling basins the water flows through a second mixing basin, where a small dose of alum is added, and on to the filters. It has been found that the iron may be removed completely by the use of from .7 to 1 grain of lime and that sufficient floc for filtration may be obtained with from .1 to .2 grains of alum per gallon of water.

A limited amount of softening is possible with this plant and as a matter of fact from 10 to 15 per cent of the total hardness of the water is removed by the treatment given the water during the past few months, which has consisted of 2.7 grains of lime and .2 grain of alum per gallon.

The Water Supply.—The water supply of Albuquerque is taken from five systems of wells, all of which are located within the city limits and tap what is probably the underflow of the Rio Grande River. The hardness and iron content of the water as well as the yield of the wells in the five systems varies widely, as shown in Table I, and there also seems to be a trend toward increased hardness in most of the wells, as shown by the difference in the results taken during July, 1926, and November, 1929.

Water of varying hardness can be obtained by using various combinations of these well systems as shown in Table II.

Tests.—This shows that the production of softer water at this particular plant is largely a matter of selection and the use of so many varying kinds of water complicates the treatment problem somewhat. Frequent tests are necessary to determine the character of the raw water and the effect of treatment. These tests, which consist of alkalinity and permanent hardness determinations, are made at Albuquerque daily, or oftener if the raw water combination is changed and the chemical feed is checked at intervals of two hours. This record is kept on a daily log sheet together with the record of flow through the plant and filter record. The daily log sheets are summarized each month on a form which shows at a glance the total and average daily amount of water treated, the chemicals used and the effect of treatment.

The December operating record, for instance, showed that a treatment of 2.7 grains of hydrated lime and .2 grains of alum per gallon of water removed all of the iron and 42 p.p.m. of hardness (or 13 per cent of total hardness) from the water at a cost for chemicals of $3.70 per million gallons.

This plant is operated by one man during the daylight shift, and during the night one of the pump house employees makes regular trips to keep the hoppers of the chemical feed machines full and to see that the plant is operating properly.

The city is at present prospecting for an additional supply and hopes to get a softer water. This seems possible since several supplies exist. The Santa Fe, for instance, has three wells which furnish water with from 76 to 140 p.p.m. of total hardness and several of the laundries have similar supplies.

As stated above, this plant has been successful in the removal of iron and carbon dioxide and has gone about as far into the softening end of the game as is advisable.

Acknowledgment.—The foregoing is an abstract of a paper presented before the Rocky Mountain Section of the American Water Works Association.

Table I

Wells	Date of sample	Alkalinity of temporary	Non-carbonate or permanent	Total	Iron	Probable yield in gallons per minute
Kent Sturgis	1926	134	189	323	1.8	550
Kent Sturgis	1929	154	256	410	.2	
Broadway	1926	127	285	412	2.9	200
Broadway	1929	126	316	442	7.0	
Mountain Road	1926	132	55	182	0.1	625
Mountain Road	1929	134	88	222	Trace	
5th & Mt. Road	1926	200	84	284	.3	925
5th & Mt. Road	1929	172	74	246	Trace	
Plant Wells	1926	145	52	197	.6	500
Plant Wells	1929	138	172	310	Trace	

Table II

Well Systems in Use	Probable Yield, Gallons per Minute	Alkalinity or Temporary Hardness	Non-carbonate or Permanent Hardness	Total Hardness
1. Broadway	200	126	316	442
2. Kent Sturgis	550	154	256	410
3. Mt. Road	625	134	88	222
4. 5th & Mt. Road	925	172	74	246
5. Plant Wells	500	138	172	310
All wells	2,800	151	149	300
1, 2, 3, 5	1,875	140	187	327
2, 3, 5	1,675	141	171	312
2, 3, 4, 5	2,600	152	137	289
3, 4, 5	2,050	152	104	256
3, 4	1,550	156	83	239

Trunk Main Surveys and Distribution Studies

Use of Pitometer in Securing Data on Normal Flow of Water in Large Feed Mains, Together with Tests of Cement Lined and Talbot Lined Pipe

By H. E. BECKWITH

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As a natural result of the measurements made for water waste control, a considerable field has recently been developed for the use of the pitometer in securing data on the normal flow of water in large feed mains, the test on such mains to determine the Williams and Hazens coefficient, and in short to secure all other similar data which might be of value in the design of additions or reinforcements to the system. Investigations of this nature are known as trunk main surveys and distribution studies.

It is believed that illustrative cases will best serve to show the nature of the data secured in making these surveys, and its value to the engineer and operator. Besides which, this paper is not intended as a technical treatise. Its sole purpose is to call your attention to some conditions we have found, in the belief that our experiences may perchance help you in solving some problems of your own. The following example of conditions discovered by our company were discovered by different men, and are so chosen as to represent possible conditons in various parts of the country.

Normal Flow Disturbed by Closed Valves.—One of the engineers found the following interesting condition (Fig. 1) in a city of some 50,000 population. The city theoretically was being fed through two 20-in. mains, one 12-in. main, one 10-in. main, and some 6-in. mains. One of the 20-in. mains was found to be shut off by a valve broken closed, and the other was found to be shut off due to the fact that a valve on it closed by turning in a direction opposite to that of the rest of the valves in the system. As a result, the city was being fed through one 12-in. line, one 10-in. line and three 6-in. lines. This condition had prevailed for at least six years. Upon the opening of these 20-in. lines, the pressure at a fire station in the city which had been 40 lb. was increased to 75 lb.

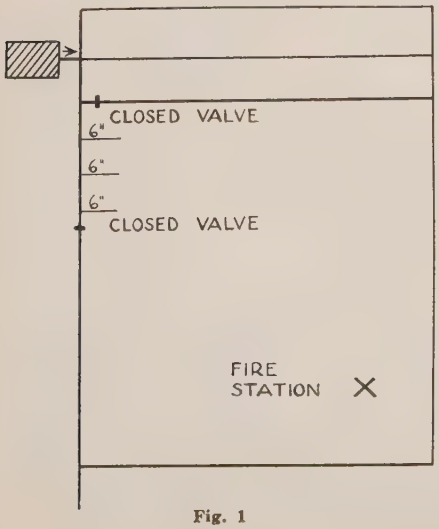


Fig. 1

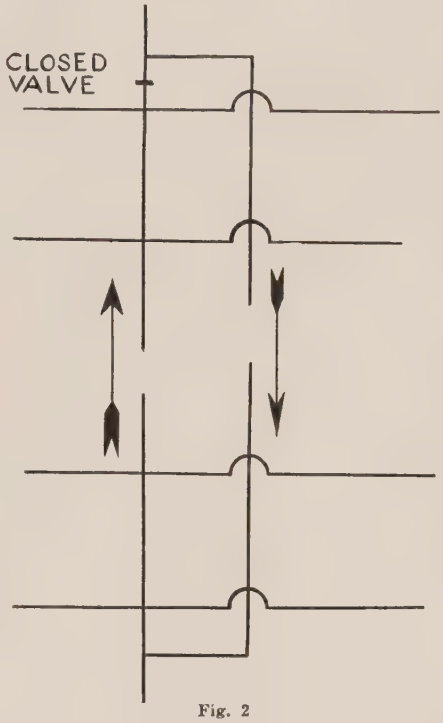


Fig. 2

Another similar instance was found in the course of our investigation in one of this country's major cities. Two widely separated portions of the system were connected by a 16-in. loop line, which line also served as a main feed for the territory in between. Along the length of this line, twelve valves were found closed, with their by-passes open, thereby practically nullifying the valve of this connection.

About a year ago a study (see Fig. 2) was being made of the existing conditions at the Allegheny Water Co. at Altoona, Pa., with a view to strengthening the system. This system, which supplies several small communities, is essentially one long feed main with laterals leading off to each side. At one point, this feed main had, for 1½ miles of its length, been paralleled by another main which was not connected to any of the laterals and which was only connected to the original feed main at the two ends. In plotting the hydraulic grade line along this stretch, it was found to be lower along the pipe than at either end of the paralleled section. This was caused by the valve on the reservoir end of the "old" line being closed and all water being compelled to flow through the new line to the point of their connection 1½ miles away and then flow back toward the closed value. As is usually the case, the reason for this valve being closed was that it operated contrary to the majority of the valves in the system.

In each of these instances the normal flows were disturbed by closed valves. But our investigations often lead to the discovery that the maximum efficiency of the lines is not reached because of other reasons.

There was, for instance, one main feed line which was not doing any work because at one point it lay above the level of the water in the reservoir from which it fed.

Increasing Capacity by Equalizing Loads.—Then there is the case (Fig. 3) of the two 48-in. lines which supply West Philadelphia with low pressure water from the Belmont filter plant. Our test at the inlet end of these pipes showed a maximum velocity in

Fig. 3

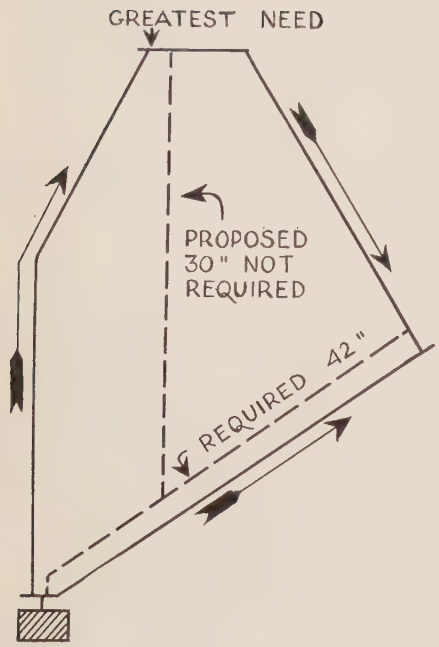


Fig. 4

one of 2.5 ft. per second, and in the other a maximum velocity of 3.9 ft. per second. Our investigations showed that this inequality in flow was caused by a choking of the pipe having the lower flow. This occurred at Belmont Road and Montgomery Ave. At this point the 48-in. main was broken up into a 30-in. main having a maximum velocity of 4.8 ft. per second, and a 20-in. main having a maximum velocity of 4.7 ft. per second. The carrying capacity of these two mains was considerably less than the capacity of the 48-in. main feeding them, and the large main was therefore unable to work at its maximum capacity. By adequately connecting the two 48-in. lines at the point where the one breaks up into the two smaller mains, the load would be equalized and the carrying capacity of the installation considerably increased.

How Equal Distribution of Load Was Secured.—A situation the reverse of this was discovered in Pittsburgh, through our tests on the two 20-in. mains which convey water from the Herron Hill Pumping Station to the Squirrel Hill District. These mains are of approximately the same length, the same age, and our tests showed them to have approximately the same Williams and Hazens coefficient. Yet our measurements showed a maximum velocity in one of 1.54 ft. per second, and in the other of 2.80 ft. per second. This inequality of flow was found to be caused by unequal feeds to the two mains at the pump statlion. One main was fed by a 20-in. connection and a 16-in. connection, whereas the other main was fed by one 12-in. connection. By increasing the feed to this latter main, the load will be equally distributed and the friction loss considerably reduced.

The conditions of flow (Fig. 4) found to exist in the 30-in. Hawley-Forest-Detroit-Nesselwood-Erie-Cherry Broadway loop in Toledo illustrate a somewhat different variation of the same thing. An automobile factory is situated on that part of the loop furthest from the pumping station. The underwriters' tests showed the flow of water at this point to be insufficient and the system in need of reinforcement. It had been supposed that the point of equalization of flow in this loop was at the automobile factory. Our tests, however, showed that the flow equalized at a point on the loop much closer to the pumping station. The plans for reinforcements had provided for a 42-in. line from the pumping station to the point found to be the real point of equalization, and a 30-in. line to be taken off this proposed 42-in. line at a point near the pumping station and running to the general location of the automobile factory. However, a study of the conditions as shown by our tests proved that, after the 42-in. line was built as planned, the flow between the present point of equalization and the automobile factory would be reversed so as to feed toward the factory, and thereby furnish a supply entirely adequate to meet the demands for fire protection. The contemplated 30-in. line was thereby proved to be unnecessary, and its cost saved.

Of considerable importance also are the tests on the main feed lines for loss of head and the determination of the value of the Williams and Hazen coefficient. All waters do not tuberculate pipe at the same rate, and it is of considerable value to make tests at each plant to determine exactly what the effect of the local water is on the mains. These values will often be found to vary widely from the values given in tables at present available.

Tests of Cement Lined and Talbot Lined Pipe.—In order that the results of certain tests made last spring at the plant of the National Tube Co. at Versailles, Pa., may be made available to the profession, it has been requested that they be included in this paper. These tests were made to determine the carrying capacity of new cement-lined and of new "Talbot"-lined pipe. The preparations for the tests were costly and were of such a nature as to make them practically laboratory tests. The following extract from the report on this work gives the details and results.

The general layout of the piping for this test is shown in Fig. 5.

The water was pumped from a tank by means of a centrifugal pump driven by a variable speed motor. It first passed through about 1,500 ft. of pipe laid perfectly straight and perfectly level. Then by means of two 90 deg. bends the direction of flow was turned back toward the tank, and the water passed through another 1,500 ft. of straight, level pipe back into the tank from which it was first pumped. For purposes of comparison the two sections of the main were Talbot-lined and cement-lined pipe respectively. Velocities were varied by varying the speed of the pump. While these sections of pipe were each 1,500 ft. in length, only 1,000 ft. of each was used in the tests, the extra length being laid so that all eddies and turbulence of flow would be eliminated before the water reached the test section. The diameters used were those of the interior of the lining, and were determined by calipering the pipe at the gauging points.

The velocities were measured by a pitometer, while the loss in head was measured by a mercury filled manometer. Pressure was transmitted to the manometer from the ends of the test section by means of ½-in. piping, all necessary flexible connections being made by rubber tubing.

It was impossible to obtain flows under 2.56 ft. per second, as the pump set up a surge when throttled below that point.

Several tests were run until everything was co-ordinated and working smoothly. Our official tests, therefore, start with Test No. 6. All computations were made with the slide rule.

The results of the tests are shown in Table I.

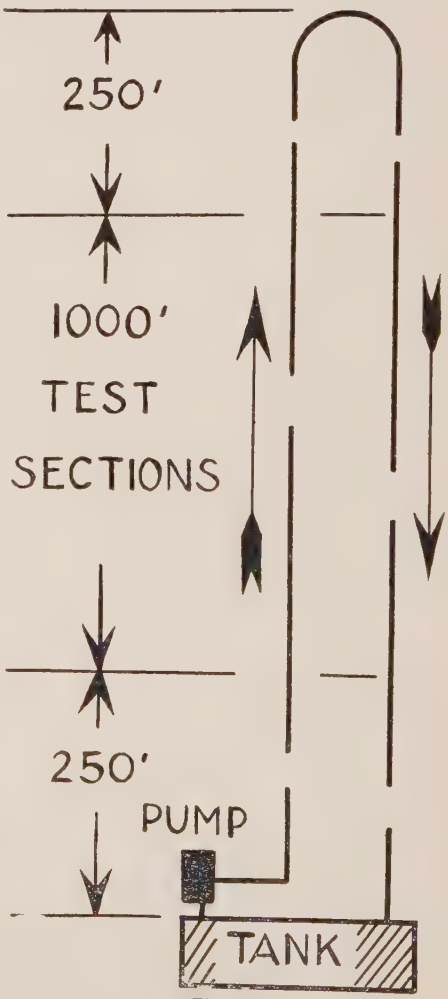


Fig. 5

Table I—Results of Tests of Talbot Lined and Cement Lined Pipe

	Talbot Lined Diameter 11.31 In. Ratio of Average Velocity to Center Velocity 88.6% Length of Pipe Under Test 1,000 Ft.			Cement Lined Diameter 11.44 In. Ratio of Aevareg Velocity to Center Velocity 84.8% Length of Pipe Under Test 1,000 Ft.		
No. Test	Velocity in Feet per Second	Loss ofHead in Feet	Williams & Hazen Coeff.	Velocity in Feet per Second	Loss of Head in Feet	Williams & Hazen Coeff.
12	2.60	1.63	158	2.56	1.70	150
11	3.63	3.01	158	3.58	3.21	149
10	5.08	5.65	158	5.01	6.06	148
6	5.74	6.87	160	5.63	7.57	148
7	7.01	9.95	160	6.87	10.88	148
8	8.36	13.90	158	8.20	15.38	147
9	9.42	17.40	159	9.24	19.35	147

No Talbot lined pipe has been installed long enough to make possible tests on installations which have been in service over any considerable period of time. You may, however, in view of the present attention being given to cement-lined pipes, be interested in some tests recently made on cement pipe at Greensburg, Pa. This pipe is built of an inside layer of cement, then a layer of wrought iron, then a layer of cement, and then another layer of wrought iron. This pipe was laid in 1888, so that the tests show the effect of 41 years of service. Long lengths of this pipe were laid for conduit purposes and made ideal subjects for tests. The water carried is a mountain water and the pipe is laid over moderately broken territory.

Tests of Cement Lined Pipe.—These tests were made under service conditions and the losses include losses from bends, etc. The flows were measured with the pitometer and the friction losses measured by carefully calibrated Bristol recording gauges. Two pieces of pipe were tested, one 14-in. pipe 12,581 ft. in length, and one 12-in. pipe 7,854 ft. in length. In both cases the Williams and Hazen coefficient was found to be 105. These tests were made by Mr. Guy Morrow and Mr. John Kelliher of the Community Water Service Co., and it is through their courtesy that I am able to pass this information on to you. The details of the tests follow:

Loss-of-Head Test of the Wetsmoreland Water Co. Made Sept. 21, 1929

Fourteen-inch cement line from Immel Reservoir and a Determination of "C" in Hazen & Williams formula

Flow Measurements

Location	Pitometer Size Coefficient	Consumption G. P. D.
Sta. 0-1+73	14"—86%	1,684,000
Sta. 124+08	14"—82.55%	1,671,000

Waste 13.000 G. P. D.

Loss-of-Head Test

Location—0-1+73		124+08
Size—14"		14"
Velocity—2.55	Average 2.54	2.53
Elevation—1401.91		1140.87
Water Level—1417.52		1384.61

Total Loss—32.91
Length—12,581 Ft.
Loss per 1000—2.616
Coefficient—105
Pipe Diameter 13 13/16
Date laid, 1888

Loss-of-Head Test of the Westmoreland Water Co., Sept. 21, 1929

Loss-of-Heal Test and a determination of "C" in Hazen & Williams formula. Was made on 12-in. cement-lined from a point below Dry Ridge Reservoir to a point near the Jamison Venturia Meter with the following results:

Flow Measurements

Location	Pitometer Size Coefficient	Consumption G. P. D.
Sta. 375+40	12"—0.83	1,313,000
Sta. 454+00	12"—0.79	1,228,000

Loss 85,000 G. P. D.

Loss-of-Head Test

Location—Sta. 375+46		Sta. 454+00
Size—12"		12"
Velocity 2.687	Average 2.597	2.508
Head—130		107.5
Elevation—1170.14		1167.48
Water Level—1300.14		1274.98

Total Loss—25.16
Length—7854
Loss per 1000—3,203
Coefficient—105
Date laid, 1888

Acknowledgment.—The foregoing is an abstract of a paper presented at the 34th annual meeting of the Pennsylvania Water Works Association.

Famous Hydraulic Engineer Dies

Clemens Herschel, one of the most prominent hydraulic engineers of this country, died March 1 at his home in Glenwood, N. J., after a short illness. His health had been impaired during the last few months, but until quite recently he went to his office at 2 Wall St., New York City, with regularity.

Mr. Herschel was born in Boston, Mass., on March 23, 1842. He was graduated from the Lawrence Scientific School of Harvard University in 1860. He first engaged in bridge designing and construction and later was employed on the sewer system of Boston. Later he turned his attention to hydraulic engineering and from 1879 to 1889, as engineer for the Holyoke Water Power Co. of Holyoke, Mass., did much research and made many developments in the field of water power, including the famous Holyoke testing flume, which marked the beginning in the scientific design of the modern water power wheels. During this period he also made the designs for the masonry dam across the Connecticut River at Holyoke. Mr. Herschel was engineer and superintendent of the East Jersey Water Co. from 1889 to 1900, during which time he developed a water supply for Newark, N. J., and vicinity.

Since 1900 Mr. Herschel had served as consultant in many important water projects, including the Niagara Falls power problem. He was one of a commission of three engineers who examined the plans for the city tunnel of the Catskill Aqueduct in New York City in 1910 before they were approved by the Board of Estimate.

Mr. Herschel was the inventor of the Venturi meter, being awarded the Elliott Cresson gold medal of the Franklin Institute for this invention.

Mr. Herschel was vice-president of the American Society of Civil Engineers in 1915 and president in 1916. He wrote several books on hydraulics, notably a translation from "Frontinus, and the Water Supply of the City of Rome," which he compiled from notes and plans of Frontinus found in an old monastery.

New Water Supply Proposed for Northern New Jersey

The State Water Policy Commission of New Jersey, in its first report submitted March 4 to the legislature, finds that a new major water supply for the northern metropolitan district should be available for use by 1940. The so-called district includes the counties of Essex, Hudson, Bergen, Union and parts of Passaic, Somerset and Middlesex.

The development of a high level supply, impounding the upper waters of the north and south branches of the Raritan and the Musconetcong Rivers, is recommended as the next step in an orderly plan for the best use of the waters to be drawn upon for the benefit of the entire district. In the opinion of the commission and its engineers this method is exceedingly important, since it would make it possible to save the heavy cost of pumping to many communities. The consumption of the district in 1928 was about 275 million gallons daily, of which 103 millions were pumped from surface supplies and 50 millions from well supplies.

Residental growth in suburban areas is increasing very rapidly and the above plan would provide for the storage of water at points more remote from thickly settled areas or those which will soon be occupied.

The report points out that the district is now supplied from 34 independent water systems, although some of these systems have interconnecting arrangements that make one available to the other in emergencies. These systems serve a population of 2,800,000. Some of them are privately owned and others are under the control of municipalities.

The commission made but one specific recommendation to the legislature for action at this time. This is a bill providing for a state-wide referendum on a bond issue, the suggested amount being $7,000,000, that would result in lending the credit of the state for the purpose of acquiring major undeveloped sources of supply and the adjacent lands necessary to protect them in all parts of the state.

Montana Water Works Men Meet in April.—The 5th annual meeting of the Montana Section of the American Water Works Association will be held April 17, 18 and 19 at Missoula, Mont. H. B. Foote, Helena, Mont., is secretary.

Sanitary Defects of Ground Water Supplies

Underground Contamination of Supplies—Sanitary Defects Permitting Surface Pollution—Accidental Contamination and Defects in Storage and Distribution

By R. E. LAWRENCE
Assistant Engineer, State Board of Health of Kansas

STATISTICS show that at the present time 50 per cent of the people in Kansas depend upon public supplies as a source of water supply. About 46 per cent of this number are supplied from surface sources, that is water which is obtained from streams or impounding reservoirs. The other 54 per cent are supplied from underground sources. While the number of people receiving water from surface and underground supplies is about evenly divided, statistics further show that 82 per cent of the total number of public water supplies in Kansas are from underground sources. These figures readily indicate the importance of ground water supplies.

The unsatisfactory bacteriological quality of untreated surface water is readily admitted, and in most cases quite adequate works are provided for the purification of these waters. So thoroughly in fact is the purification perfected, that most plants treating surface waters have little difficulty in meeting the rigid standards of quality which are required of treated surface waters. Unfortunately, most people are inclined to place the label of absolute safety on all water from underground sources, and popular belief has it that nothing is more pure than a clear, cold, spring or well supply. Quite contrary to this general belief, bacteriological analyses of the ground water supplies of Kansas over a period of years show a surprising frequency of contamination. Since there is considerable diversity of characteristics as to source of supply, pumpage, storage and distribution, these analyses indicate in a general way the collective sanitary defects of these supplies.

The U. S. P. H. S. Standards, as to bacteriological quality require that:

"(1) Of all the standard (10cc) portions examined, not more than 10 per cent shall show the presence of organisms of the B. coli group.

"(2) Occasionally, three or more of the five equal (10cc) portions constituting a single standard sample may show the presence of B. coli. This shall not be allowable if it occurs in more than—

"(a) Five per cent of the standard samples when twenty or more samples have been examined.

"(b) One standard sample when less than twenty samples have been examined."

What Analysis of Ground Water Supplies Showed.—Using this rigid standard as a basis, an examination of the records of Kansas ground water supplies for the year 1929 indicates that nearly 36 per cent of the supplies met the requirements. Over 25 per cent of the supplies had perfect records for the year, that is, supplies which had a record of analyses for the year without B. coli or B. aerogenes in any sample. An examination of ground water supplies with perfect records for succeeding years shows that 12.1 per cent have perfect records for two years, 6.2 per cent for three years, 4.3 per cent for four years, 3.1 per cent for five years, 2.7 per cent for six years and 1.2 per cent for seven years. Less than 1 per cent of the supplies have perfect records for eight and nine years. These data are of particular interest, since they tend to show that apparently every supply has a first time for showing contamination in samples collected for analysis. These data also indicate that there is need for very careful observation of sanitary conditions of ground water supplies on the part of engineers and public health authorities. The need of very careful protection of supplies from pollution on the part of water superintendents is apparent.

The sanitary defects which permit contamination in supplies either continuously or intermittently may be the result of accident, ignorance or poor design. Unfortunately, however, it frequently happens that contamination reaches the consumer undetected. Generally speaking, sanitary defects permitting contamination in ground water supplies may be classified as follows:

(1) Sanitary defects permitting underground contamination of supplies; (2) Sanitary defects permitting pollution of wells at the surface; (3) Accidental contamination, and defects in storage and distribution.

Defects Permitting Underground Contamination.—The comparatively shallow wells are for the most part subject to the largest variety of faults. Wells less than 30 ft. deep are frequently found to yield contamination, which may be due either to direct percolation carrying bacteria into the ground water stratum, or to holes, tree roots, or other direct ports of entry.

Shallow wells are frequently of the large open dug type, which too often are not provided with a watertight curbing or casing extending deep enough to keep out contaminated surface or very shallow ground water. Casings constructed of brick, porous concrete and vitrified clay pipe are generally unsatisfactory. The gravel wall type of well which is used in sand to increase the yield may be subject to contamination through the gravel unless properly protected. All wells should have a water-tight casing installed to a safe depth or preferably to the water-bearing stratum. Vitrified clay or concrete pipe should have tight joints. In the case of wells using gravel around the casing, the gravel should be replaced with packed clay to a depth of 6 to 12 ft. below the surface, or the dummy casing left in place from the top of the water-bearing stratum to the surface. The safe vertical depth in soil which will effectively filter out surface bacteria varies within wide limits depending on the filtering medium. For solid clay 6 ft. is usually considered a safe depth, and for fine sand, about 12 ft. Through fissured rock or joint clay, there can be no safe distance.

It frequently happens that shallow wells of satisfactory construction show continuous contamination. One city which has come to the writer's attention receives its water supply from shallow wells above an underlying stratum of limestone. The city is unsewered and many of the residences have septic tanks or cesspools. While the wells are located a reasonable distance from such contaminating influences as feed lots, stables, etc., it is quite apparent that this supply can never be satisfactorily without sterilization. Many instances have been noted where abandoned wells and test holes have been the means of polluted surface water reaching the ground water stratum. It is not at all uncommon to find school wells and private wells in small communities being contaminated directly from cesspools.

In the construction of deep wells, failure to extend the outside metal well casing to a sufficient depth and seal into a solid stratum, sometimes permits contaminated surface water or shallow ground water to get into the well. Holes in outside metal casing produced by corrosion quite often permit contamination by allowing seepage into the well. The use of light metal casing as a well tube is hardly dependable. Being subject to corrosion, holes develop more readily to admit seepage, and it becomes weakened to the point of collapse.

Probably the greatest number of sanitary defects in most ground water supplies can be traced to the poor lo-

cation of the supplies, with regard to surface drainage, flooding at times of high water, and proximity to sources of sewage contamination. The only remedy for these conditions is the establishment of the supplies when possible in more favorable locations. Adequate testing before a supply is developed insures not only the best supply available from the standpoint of chemical and bacteriological quality, but also makes possible the best selection of site from the standpoint of sanitary conditions. The comparatively small cost of testing is justifiable in practically all ground water developments.

In the development of springs, the failure to properly curb the springs may result in surface water washing directly into them during rains. Failure to cover the spring boxes or to maintain the overflow level above high water level in adjacent water courses frequently results in springs being flooded by surface water backing up directly into the springs. The use of water from springs with populated watersheds or in limestone formations should not be permitted without sterilization. Water from springs in any formation should be regarded with suspicion until the bacteriological quality of the water under all conditions has been definitely determined.

Defects Permitting Pollution of Wells at the Surface.—Those defects which have to do with the pollution of wells at the surface are for the most part defects of construction, or more particularly improper setting of pumping equipment. The committee report, Conference of State Sanitary Engineers on Development of Ground Water Supplies, which was presented at Cincinnati, O., May, 1924, points out common defects as follows:

"(1) Lack of a tight connection to close the annular opening between the well casing and pump column (sometimes called dropline or suction line).

"(2) Lack of adequate facilities for removing seepage or waste water from a well pit or pump room.

"(3) Connection of well pit or pump room to sewer or drain subject to backflow."

In order to protect well supplies against pollution through the abovementioned defects, the committee has formulated the following: "Suggested Regulations Covering the Installation of Well Pumping Machinery."

"A. Where the pump head is installed without a pit.

"1. The pump head shall be installed on a concrete base of sufficient height to permit the outside casing to extend at least 4 in. above the pump room floor, and to enable the installation of a suitable connection as under A-2.

"2. The annular opening between the outside casing and pump column shall be closed by means of a suitable connection which will effectually prevent waste water, oil or other contaminating material entering the well. Where the pump house floor is below the outside ground level, or is subject to flooding, this connection shall be made watertight.

"B. Where the pump head is installed with a pit or in a pump room below the ground level.

"1. The sides and bottom of the pit or pump room shall be constructed of watertight concrete. It is preferable that the pit be left uncovered, surrounded by a railing, to permit easy inspection by the pump operator.

"2. The annular opening between the outside casing and pump column shall be closed by means of a watertight connection capable of withstanding for 24 hours without leakage, the water pressure resulting from complete filling of the pit with water. The types of connections approved are given below in order of preference.

"a—An all flanged or threaded connection.

"b—A stuffing box connection.

"c—Metal to grouted cement connection with suitable gasket; to be used only when joint carries weight to pump column.

"3. Any vents provided for the well shall be extended by a pipe with screw or flange connections to a point above the floor level. A return ell shall be screwed on the upper end of this pipe.

"d. Drainage shall be provided for the pump pit or pump room by one of the following methods:

"a—By means of a drain consisting of a 6-in. sewer pipe with cemented joints installed in a straight line and on an even grade of not less than 0.6 ft. per 100 ft., with a small concrete bulkhead at the outlet to insure an open discharge at all times; provided that under no conditions shall this drain be connected to a sewer and that the bottom of the pit so drained is above the high water level in any adjacent watercourse.

"b—By means of a pump or ejector drawing from a sump of not less than 5 cu. ft. capacity situated so as to collect all waste water. This pump or ejector should operate automatically or be connected to some moving part of the pump head so as to operate continuously with this pump. This pump shall discharge above the pump room floor level into a suitable drain or on the surface of the ground.

"5. The bottom of the pit or pump room shall be sloped away from the top of the well casing toward the drain or sump with sufficient grade to insure ready flow. At least 6 in. difference in elevation shall be provided between top of the well casing and high water level in the sump."

The committee cites references to typical epidemics caused by pollution of wells at the surface.

In the construction of dug wells, it is common practice to build a platform over the well on which the pumping equipment is set. Too often this platform is not tight enough to protect the well from direct contamination.

Accidental Contamination and Defects in Storage and Distribution.—Many cities with very good groundwater supplies and long records of satisfactory bacteriological analyses, oftentimes find contamination suddenly showing in samples collected for analysis. A careful investigation into the reason for the pollution may show that a pump has been pulled for repair or that repairs or changes have been made in the distribution system. One city in Kansas recently had such an experience, when, after a long period of satisfactory bacteriological analyses, samples were collected and found to contain organisms of the Coli-aerogenes group. This particular supply is obtained from two wells and shortly before the samples were collected meters had been installed for the purpose of measuring the pumpage from each well. Since all of the water pumped passed through the meters, the contamination was scattered generally through the distribution system. It was several weeks before traces of contamination ceased to appear in samples analyzed.

New water mains should not be placed in service until properly sterilized. Specifications covering this point provide for the use of a quantity of chloride of lime in each joint while the line is being laid. New wells can be effectively sterilized by the liberal use of chloride of lime during construction. This is particularly important of wells of the gravel wall type which may become contaminated from the added gravel. It is important that water from new wells be safe before it is turned into the distribution system.

Most states now have regulations governing cross-connections, however, many times old forgotten piping, permits the pollution of a safe supply. All cross-connections not protected in the regulation manner should be eliminated.

The sanitary defects of storage are for the most part confined to surface reservoirs. The use of open reservoirs which hold water for distribution, which is not later sterilized, is particularly undesirable. Such stored water is subject to direct contamination from bird droppings and dust, and algae growth is fostered by exposure to light. Other defects would include leakage which would permit surface water to seep into the reservoir when the water level in the reservoir is low, and overflow connections not properly protected. The remedy for these conditions is obvious. The reservoirs should be of tight construction and covered. Overflow lines should be properly protected by screens or valves.

Where the reservoir area is so large as to make covering impracticable, sterilization is the only alternative.

Conclusion.—Statistics indicate that practically all ground-water supplies are subject to regular, intermittent, or occasional contamination, resulting from definite sanitary defects. Such contamination may be of a serious nature, and may result in a great amount of sickness and loss of life.

The occasional contamination present in many supplies of excellent sanitary aspects is usually the result of accident. This accidental contamination could in most cases be eliminated entirely by the exercise of more care on the part of the operating personnel.

The definite sanitary defects causing intermittent contamination of otherwise safe supplies can in many cases be corrected, and these supplies placed on the safe list.

Where the sanitary defects are such that difficulty is experienced in adequately safeguarding a supply, sterilization is required. Extreme cases of polluted ground-water require complete treatment as with surface supplies.

It is the purpose of public health authorities and water works men to locate and eliminate the sanitary defects causing contamination of ground-water supplies. The failure to permanently eliminate all contamination by the correction of physical defects requires in every case sterilization.

Acknowledgment.—The foregoing is a paper presented Feb. 12 at the 8th annual Three Day School at the University of Kansas and the 5th annual meeting of the Kansas Water Works Association.

Reservoirs Protected by Forestry

Reports of the United States Forest Service indicate that the use of trees for the protection of reservoirs is growing. The city water works department of Akron, O., has developed a transplant nursery in which more than 200,000 seedling trees are growing to a size that will enable them to compete with heavy sod. In Barberton, O., the city water works department began planting on a large scale this year. It is planned, along with the reforesting of idle land, to develop a wide shelter belt of pine or spruce all around the large city reservoir. Such a shelter belt prevents much debris from being carried into the water, in addition to acting as a soil binder.

Paint Hydrants to Mark Pipe Sizes

Different colors of paint are used in Trenton, N. J., to aid firemen in identifying the sizes of fire hydrants. Hydrants attached to 4-in. mains are red, those attached to 6-in. mains are red with orange tops and those reaching mains over 6 in. in diameter are red with green tops.

Damages Awarded for Death from Water-Borne Typhoid Fever

In a decision handed down on Sept. 16, the Indiana Appellate Court affirmed the Judgment awarding damages for a death from typhoid fever. Public Health Records for Nov. 29 contains the following account of the case:

"An action was brought by the administrator of a decedent's estate against the Pennsylvania R. R. Co. and the city of Fort Wayne to recover damages for the death of the decedent from typhoid fever contracted by drinking contaminated water.

"The city of Fort Wayne owned and maintained a water system and furnished water to the inhabitants of the city. The railroad company also owned a water system, taking its water from St. Marys river. In 1903 a connection was made betwen the city's potable water supply and the railroad's supply of river water, a swinging valve and two gate valves being installed to prevent the pollution of the city water by the river water. In the summer of 1923 there were many cases of typhoid fever in a section of the city served by a sewer which emptied into the river upstream from the railroad pumping station. In November, 1923, there were from 135 to 140 cases of typhoid fever in the immediate vicinity of the by-pass and connection between the river water and the city supply, and the plaintiff's decedent was one of the persons afflicted. The city water was used in every infected home in the vicinity of the connection. The plaintiff contended that the death of its decedent was due to the drinking of city water which had become polluted by river water from the railroad main, and alleged that the city and the railroad company were negligent in the maintenance of the connection. A jury trial resulted in a verdict and judgment against both defendants, and on appeal to the appellate court the judgment was affirmed.

"In its opinion the appellate court stated that 'The gate valves on each side of the swinging valve were open, and the jury was justified in finding that the swinging valve would not seat, so as to prevent water from the river flowing into the city water main."

"Further in its opinion, the court also made the following statement:

"It is comonly known that water from a river flowing through cities, towns, and thickly populated country is viewed with suspicion. The circumstances in this case were such that the reasonable probability of the river water being infected should have at all times been apparent to watchful minds, charged with the protection of public health. Both appellants knew, or should have known, that it was unsafe to allow the polluted water from the river to flow into the water mains of the city. The situation was such that the contaminated water in the railroad water main might be likened to a firebrand, and only needed a slight flame to touch it off. A leak in the by-pass was a sufficient flame to start a conflagration. Appellants should have been awake to the situation presented with the gate valve on each side of the by-pass open. They knew that, with these valves open, the only thing which would prevent the river water from being forced into the city main was the swinging check valve, which had never been inspected by either of them after its installation in 1903. As it appears to us, the jury was justified in finding that appellants were. under the facts, negligent in allowing the gate valves to be and remain open, and in not inspecting the check valve, to see that it was seating and serving the purpose for which it was intended."

Results of Cleaning Water Mains

During the past year 4,752 ft. of 8 in. and 5,313 ft. of 6 in. pipe of the distribution system of St. Louis, Mo., were cleaned, the work increasing the efficiency of the mains from an average of 30 per cent to that of 71 per cent. The following note on the work is taken from the annual report for year ending April 8, 1929, of Leonard A. Day, Water Commissioner of St. Louis.

The pipe was cleaned under the supervision of the National Water Main Cleaning Co., which furnished the cleaning equipment and the superintendent. The City Water Division furnished all labor and a foreman. All work was done at night in the downtown section. The total cost was 32-2/3 ct. per foot, including the making of excavation, cleaning the pipe, permanently repairing the street and hauling away the dirt or flushing the street. The improvements effected by cleaning are shown in Table I.

Table I.—Summary of Data on Cleaning of Water Mains in 1928

Location	Size of Main in.	Age Years	Value of "C" Before Cleaning	Value of "C" After Cleaning	Efficiency of Pipe Before Cleaning	Efficiency of Pipe After Cleaning	Diameter of Pipe Before Cleaning in.	Diameter of Pipe After Cleaning in.	Length Cleaned ft.
Clark—3rd to Broadway	6	48	28	93	23.5	77.5	4.5	6.0	675
Morgan—4th to 7th	6	59	32	85.5	26.7	71.0	5.5	5.75	945
St. Charles—7th to 12th	6	47	35	87.5	29.2	73.0	5.56	6.0	1,856
9th—Washington to Locust	6	49	32	81.0	26.7	67.5	5.0	5.75	462
Olive—7th to 12th	6	45	48	84.0	40.0	70.0	5.75	6.0	1,375
6th—Cass to Pine	8	44	44	85.4	36.6	71.0	7.69	8.0	4,752

Note: "C" is co-efficient of roughness as in Williams & Hazen formula.
A "C"=120 was used as a comparison in obtaining the efficiency of the pipe.

Experimental Sewage Treatment Work in Europe

An Interesting Outline of Recent Developments in Various Cities of Germany, France and Great Britain

By G. P. EDWARDS
Principal Assistant Chemist, The Sanitary District of Chicago

A GREAT deal of experimental work on sewage treatment is in progress in Europe, particularly in Germany. New methods are being perfected or old ones modified. New plants are being built which will test some of these new ideas.

In Germany progress is being made in the improvement of the operation and extension of the use of the submerged contact aerators. Activated sludge treatment, using wooden paddles for mechanical agitation in combination with compressed air, is being tried by many cities because of the expected low overall power requirement. The rotation of sludge, in order to speed digestion and to increase the yield of gas, is receiving particular attention. The heating of digesting sludge and the collection of gases are becoming more important, especially for the disposal of the increased amounts of sludge from submerged contact aerators and the activated sludge process. In great Britain a great deal of interesting experimental work is being done on reaeration of activated sludge. The experimental work on different types of activated sludge carried on by the City of Paris will determine the type of activated sludge plant to be constructed there in the near future.

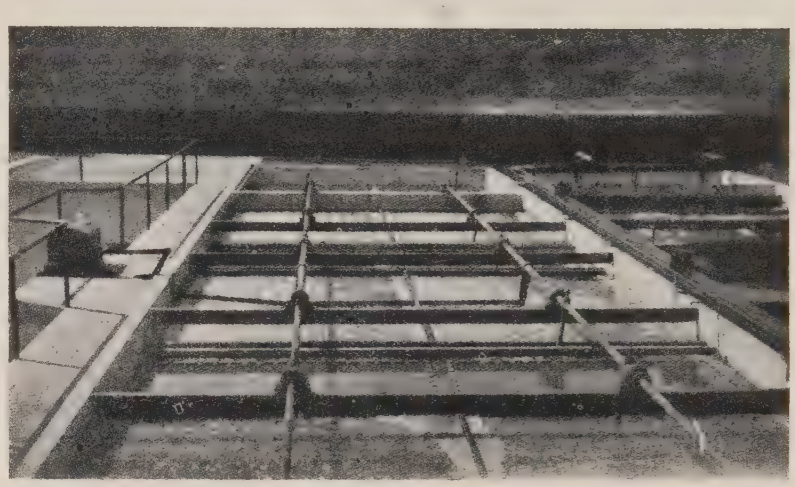


Fig. 2—Stage Operation of Submerged Contact Aerators—Rellinghausen

Germany

Ruhrverband-Rellinghausen.—Some very interesting experiments on stage operation of sewage treatment processes were started early in August, 1929. One series comprises three paddle-wheel aeration tanks, with settling tanks between each aeration unit (Fig. 1). A total aeration period of 2½ hours is being used. The volume of air required is about half the volume of sewage treated (0.07 cu. ft. per gallon). Another series of tanks consists of three stages of submerged contact aerators, with settling tanks between each stage (Fig. 2). A total detention period of 1.5 hours is being tried. The racks, instead of hanging vertically, are fixed on pivots so that they may be suspended at a small angle from the vertical. They are turned from time to time so that either side may be exposed to the air.

Different materials are being tried as contact surfaces in the submerged contact aerators. Pieces of cork 2 or 3 in. in diameter are being used. When in operation the cork is held down by a wire netting. When the wire netting is removed the cork floats and cleans itself. To replace the cork the netting must merely be fastened down. At Iserlohn burlap-covered frames were being installed.

A modified Dorr clarifier under construction will contain a deep sump in the center large enough to permit sludge accumulations of 10 to 11 hours. It is proposed to add ripe sludge intermittently to the sump in order to prevent acid digestion during the storage period.

Hattingen.—An interesting type of grit chamber construction is installed at the Hattingen treatment works (Fig. 3). It is designed to maintain a rate of approximately 1 ft. per second at all flows. As shown in the illustration, the grit chamber is divided into two sections. During dry weather only one section is used, but during storms both parts are thrown into service.

Two stages of submerged contact aerators are being tested. The total detention period is 2.5 hours, which is divided into one .075-hour period for each of the two aerators and one 0.50-hour period for each of the settling tanks.

Mansfeld.—The Mansfeld plant offers an example of the treatment of industrial wastes with the aid of submerged contact aerators and activated sludge. The sewage reaches the plant from two sources in two separate sewers.

About 35 per cent of the total sewage, in one sewer, contains two grams of phenol per liter, introduced in by-products coke wastes. This waste is first settled in an underdrained settling basin for four hours (Fig. 4). The lime and tar settle out. When the beds are full of sludge, they are withdrawn from service, the sludge is dried

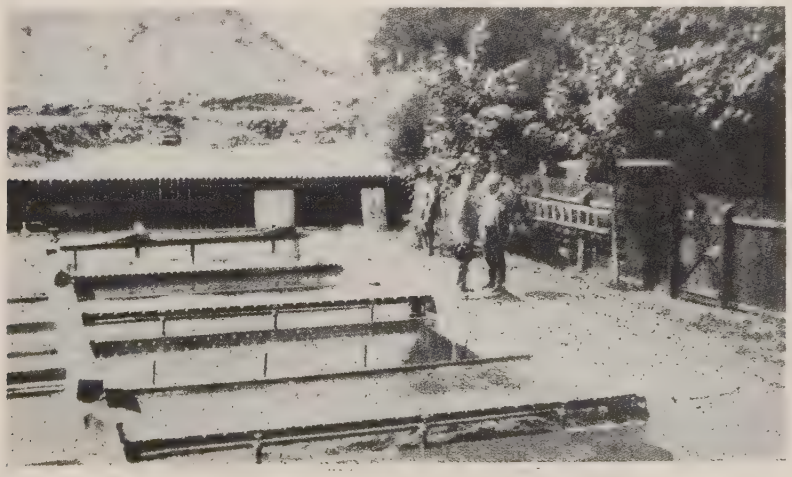


Fig. 1—Stage Operation of Paddle-Wheel Activated Sludge—Rellinghausen

Fig. 3—Grit Chamber—Hattingen

and removed and the basin is again used for settling.

The remaining 65 per cent, in a second sewer, is domestic sewage from 3,000 people. This passes first through an Imhoff tank, which has been in service twenty years. The settled sewage is mixed with the settled phenol waste. The mixture, containing about 700 p.p.m. phenol, is first treated in submerged contact aerators and then in activated sludge tanks. The contact aerators effect a 30 per cent reduction in phenol and the pH is lowered from

Fig. 4—Underdrained Settling Basins—Mansfiel

8.5 or 9.0 to 2.0. The proportion of air to sewage is about 6.7 to 1 (0.9 cu. ft. per gal.). The proportion of air to sewage in the paddle-wheel activated sludge tank, with a five-hour period, is about 13 to 1 (1.7 cu. ft. per gal.). The effluent contains less than 25 p.p.m. phenol.

Activated sludge without the tauchkörper was used unsuccessfully for a year. Larger amounts of phenol than usual stopped all purifying action in the aeration tanks. The tauchkörper seems to be less sensitive to trade wastes, in general, and especially to sudden variations in amounts of waste.

Iserlohn has the first sewage treatment plant operated solely by power generated by the gases of digestion. No outside source of power is used in the plant. The treatment works consist of Imhoff tanks, submerged contact aerators (Fig. 5) and paddle-wheel activated sludge. Three cubic meters of gas per capita per year (0.29 cu. ft. per capita per day) have been obtained from the Imhoff tanks from the preliminary settled solids alone. An equal amount of gas is expected from the digestion of excess activated sludge and the sludge from the tauchkörper.

Emschergenossenschaft-Essen-Nord.—A new type of settling tank at Essen-Nord seems to show promise of effectively dewatering sludge with a short storage period. An old storm water settling tank has been converted into a preliminary settling tank by installing a deep well in the center (Fig. 6). The sewage enters the tank at the center and flows to the sides. The solids settling in the tank are removed by a mechanical revolving scraper which forces the sludge and scum into slots in the center well. The tank treats about 470,000 gal. per hour. With 20 to 25 minute detention periods, about 75 per cent of the settleable solids are removed. The cost of construction is estimated as being less than the cost of fine screens for a like amount of sewage.

Gelsenkirchen.—An interesting series of experiments on the heating and rotation of sludge has been started at Gelsenkirchen. The sewage received at the treatment works is settled in Imhoff tanks, but since the digestion space is too small for satisfactory operation, six separate sludge digestion tanks, each with a capacity of about 180,000 cu. ft., have been constructed (Fig. 7). The fixed cover is lined with sheet lead 1½ mm. thick in order to prevent gas leaks, and it is insulated by a covering of earth. The tanks are fitted wih apparatus for rotating the sludge. To determine the effect of rotation and of heating, the six tanks are being operated as follows:

1—Sludge rotated, not heated.
2—Sludge quiescent, not heated.
3 and 4—Sludge quiescent, heated.
5 and 6—Sludge rotated, heated.

After digestion for several weeks in the Imhoff tanks, the sludge is pumped to the secondary digestion tanks. Before entering Tanks 3, 4, 5 and 6, the sludge is heated to about 25° C. in heat exchangers. As these tanks are operated under identical conditions in other respects, accurate data should be obtained concerning the advantages and disadvantages of rotating and heating sludge.

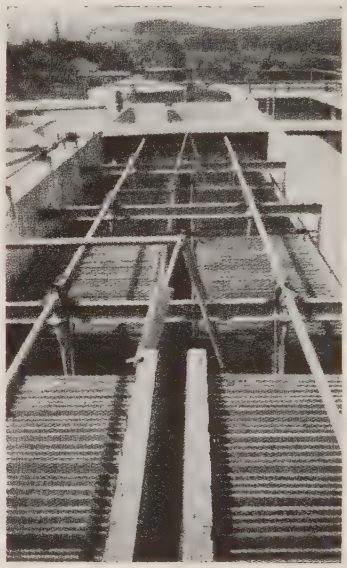


Fig. 5—Submerged Contact Aerators—Iserlohn

Fig. 6—Preliminary Settling Tank—Essen-Nord

Leipzig.—An experimental plant has been constructed at Rosenthal which includes Imhoff tanks, submerged contact aerators and paddle-wheel activated sludge tanks. A sewage flow of about 10,000 to 15,000 gal. per hour is treated. The sewage as received is very strong and septic. The paddle-wheel activated sludge tank requires a portion of air to sewage of 6 to 1 (0.8 cu. ft. per gal.) (Fig. 8). Compressed-air aeration at Leipzig requires a proportion of 10 to 1 (1.3 cu. ft. per gal.). The excess activated sludge and sludge from the tauchkörpers are digested in the Imhoff tanks. Two new tanks are under construction, one for the reaeration of activated sludge and the other for installation of the Haworth process of mechanical aeration. Experimental work at the new treatment works at Wahren has indicated that the use of tauchkörpers before the paddle-wheel activated sludge tanks will reduce the aeration period in the activated sludge from 10 or 12 hours to 4 hours.

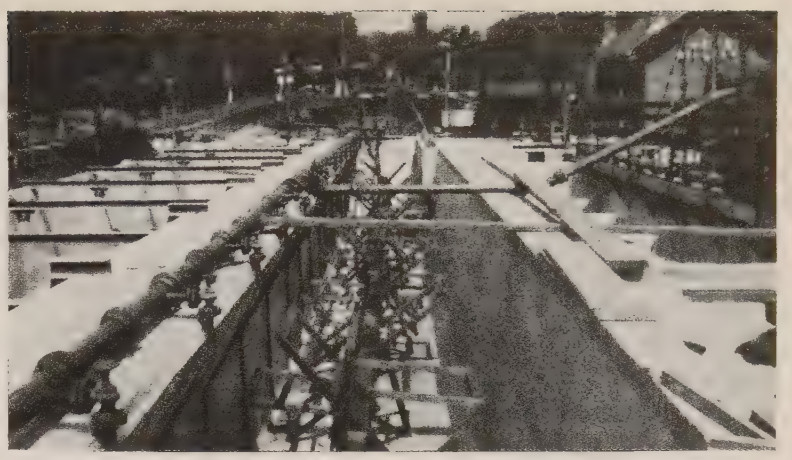
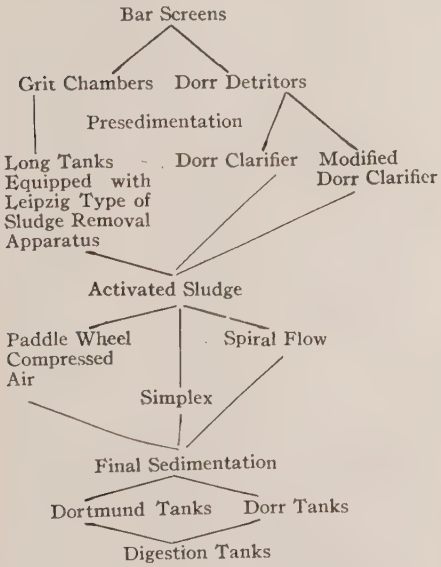


Fig. 8—Paddle-Wheel Aeration Tanks—Leipzig

Berlin.—The Stahnsdorf treatment works now under construction will really be operated on a large-scale experimental basis. The plant, which will have a capacity of about 48 million gallons per 24 hours, will be so arranged that many types of apparatus and treatment can be used. The following diagram shows the proposed arrangement:



All the sewage will pass through the sedimentation tanks, but only about 24 million gallons, or approximately the present dry-weather flow, will be treated by activated sludge. From small-scale operation it was determined that the aeration period should be about 6 hours with 20 per cent returned sludge. About 6 volumes of air to one volume of sewage (0.8 cu. ft. per gal.) will be necessary. Twenty aeration tanks 70 ft. wide, 230 ft. long and 13 ft. deep are being built.

The excess activated sludge and preliminary sludge will be digested three days to dewater it before it will be pumped to the final digestion tank. It will pass through heat exchangers similar to those being used at Gelsenkirchen, in which it will be heated to 21° to 23° C. before entering the final digestion tanks. There it will be digested about three months. Sludge rotation according to the Prüss scheme will be used in some of the tanks. Gas will be collected and used for power.

Fig. 7—Separate Sludge Digestion Tanks Fittel with Sludge Rotation Apparatus—Gelsenkirchen

Small-scale sludge digestion experiments with the Prüss sludge rotation scheme have been carried on for nine months. According to the data, the sludge has digested more rapidly and 20 to 30 per cent more gas has been obtained than without rotation. The gas contained about 18 to 20 per cent more carbon dioxide than was found in the gas from the non-rotated sludge.

France

Paris.—The experimental station at Colombes has investigated three sys-

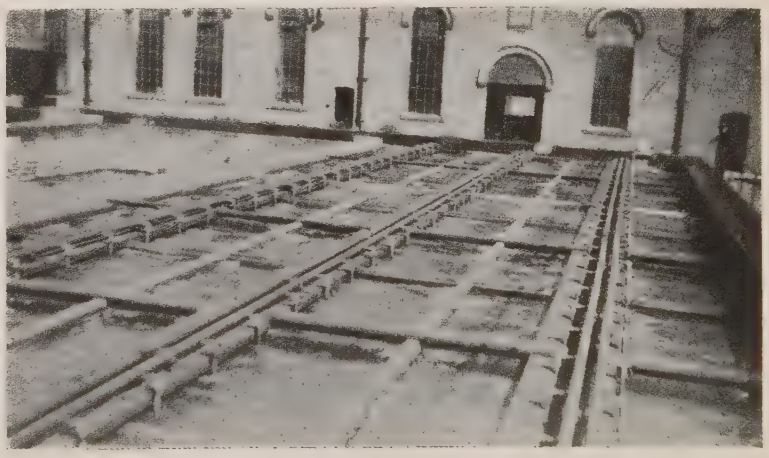


Fig. 9—Experimental Activated Sludge Plant—Glasgow

tems of activated sludge: simplex, diffused air and the Lamy process. The latter scheme consists of a tank with a vertical down-well, which reaches nearly to the bottom of the tank. The sewage, returned sludge and air are added at the top of the trapped down-well, flow out of the bottom and rise to the surface. No data on operation were available.

Great Britain

Sheffield.—Haworth is trying one of his aeration units on a fill-and-draw basis to eliminate the necessity of using nine small hopper-bottom settling tanks for one aeration unit. The main objection to fill-and-draw schemes is the time necessary for filling and drawing. In general practice, Haworth empties a tank in 45 minutes without disturbing the settled sludge. The tank is 3 ft. deep and has a flat bottom, except for a 7-ft. sump at one end. The tank is filled with sewage and the required amount of sludge and the contents are circulated for the customary period. The paddles are shut off, the sludge allowed to settle one-half hour, and the clear supernatant liquor and the excess activated sludge are drawn off from the deep end of the tank. An automatic device gradually lowers the level of the drain. The tank is then refilled and the paddles started. The operation of drawing is almost entirely automatic and requires a minimum of labor. Since the tanks had been in operation only a few weeks, no data were available.

Glasgow.—At Shieldhall an experimental spiral-flow activated sludge tank, which has been made from an old settling tank, treats about 300,000 gal. per day (Fig. 9). The sewage requires 1 cu. ft. of air per gallon with an aeration period of 6¼ hours. Re-aeration of sludge had been used for some time successfully, but during the summer it was discontinued. In a short time poor results were noted and re-aeration was resumed.

Birmingham.—Important work on short-period aeration of settled sewage before treatment on sprinkling filters is showing very good results. The capacity of the filters is being increased about twice. A new aeration unit to treat 12,000,000 U. S. gallons per day, which is about one-third of the total settled sewage received at Minworth, is about to go into operation. The new tanks will be of the diffused-air type with a 60 deg. sloping bottom on both sides of a row of porous plates. Pre-aeration of the settled sewage before addition of the activated sludge will be tried. The sewage with the activated sludge will be aerated one hour. The sludge will be re-aerated four or five hours.

Interesting work is also being carried on at Manchester, but time did not permit a visit to this city.

Acknowledgment. The foregoing is reprinted from the January Sewage Works Journal, the official publication of the Federation of Sewage Works Association.

Liability of City for Act of Health Officer

An interesting decision on the above subject was handed down Oct. 29, 1929, by the Supreme Court of the State of Ohio in the case of the City of Salem vs. Harding (169 IV. E. 457). Public Health Report for Feb. 7 comments as follows:

The city of Salem owned its public water system, the water being pumped from deep wells and conducted to a central reservoir. The water from one group of wells was conducted to the reservoir by means of a gravity line constructed of vitrified pipe with cemented joints. Not many feet from this gravity line and running parallel thereto was a sewer constructed of clay pipe without cemented joints. Property owners had been ordered to disconnect from this sewer, but such orders were apparently not complied with by everyone. Thereupon the city health officer, in conjunction with an employee of the service department of the city, plugged the outlet of the sewer. It was claimed that this caused the sewage to back up until the pressure was such that the sewage filtered through the intervening soil into the gravity water supply line.

The plaintiff in the trial court brought action against the city to recover damages because of typhoid fever contracted by his daughter as a result of the impure water supply, his action being grounded upon a claim that the city had been negligent. A verdict in favor of the city was rendered in the trial court, but on appeal to the court of appeals the judgment was reversed on the sole ground that the trial court had erroneously charged the jury as follows: That, even though the jury should find that the gravity line was contaminated by the plugging of the sewer, thereby forcing pollution into said gravity line, the verdict must nevertheless be for the defendant if the plugging was done by and under the instructions of the board of health or health officers of the city, and also that no action could be maintained or recovery had against the city based upon any acts of negligence either of commission or omission of its board of health or health officers.

The city appealed and the supreme court affirmed the judgment of the court of appeals. After citing another case to the effect that, while the construction and institution of a sewer system was a governmental matter, the operation and upkeep of sewers was a proprietary function, the supreme court said: "Still adhering to the proposition that the construction and institution of a sewer system is a governmental function, we are nevertheless of the opinion that the city is liable for any obstruction thereto, which is known to the city, if the city through its proper officers knew or in the exercise of ordinary care should have known that the obstruction would have an injurious effect upon life or property. The city being responsible for its negligence upon the foregoing principles and authorities, it may not escape that responsibility on the sole ground that it was acting in the exercise of its police power."

Another point determined was that the city was not a guarantor of the purity and wholesomeness of its water supply.

Compressed Air Cleans Concrete Forms

A useful device for cleaning out forms before pouring concrete was employed in the construction of the new Lambton Mills bridge on the outskirts of Toronto, Ont. A ¾-in. pipe was flattened somewhat at one end and attached to a rubber hose, which was connected up with a source of compressed air. An air line was brought along the deck of the bridge from the compressor and tapped at intervals. Just before pouring concrete, the air was turned on and the end of the pipe pushed down between the reinforcing bars, with the result that chips of wood and other forms of rubbish were blown to one end where they could be removed.

Salaries of County Officials.—The County Bureau of Efficiency of Los Angeles County, California, has published a "Survey of Salaries" wherein amounts paid positions in county service are compared with those for similar positions in 155 private concerns of that city. It was found that out of 83 categories compared, the county paid more than private employers in 55 classifications and less in 28. On the whole, it was concluded that public employment does not suffer in comparison with service in private concerns in that municipality.

Green Concrete and Sea Water

Special precautions are taken by the Delaware, Lackawanna & Western R. R. in protecting green concrete which is to be exposed to sea water. If possible, the water is kept from the concrete for 30 days. The concrete is mixed extra rich and rather dry, the amount of water being kept to 5 gal. per bag of cement. It is recommended that all concrete exposed to sea water be given an asphaltic protective coating.

Pipe Protectors for Fire Hydrants

Fire hydrants in New York City are protected by pieces of steel or cast-iron pipe filled with concrete. Pipe from 6 to 8 in. in diameter is used, and it is placed with about three feet in the ground and enough projecting above to protect the hydrant. A pipe protector is placed on each side of a hydrant likely to be hit by motorists.

Experiences of a Filter Plant Trouble Shooter

Preparation of Water for Filtration—The Jar Test—Red Water Troubles—The Odor and Taste Problem—How Air Binding Was Eliminated—Maintenance of Filter Beds

By L. E. WICKERSHAM

Assistant Sanitary Engineer, American Water Works & Electric Co., New York City

PRESENT-DAY practice in water purification has become simplified materially over that of years past, to a large extent through the efforts of those scientifically engaged in the design of filter plants, in the production of improved filter appurtences and mechanical equipment for more accurate control of chemical feed, and in the study, experiments and research work done on various problems which have confronted those engaged in this art.

The trend of time, the same as in other fields, requires water works to be efficiently supervised and operated in order that the finished water be of high standard and above reproach. Many of the water supplies, heretofore furnished, were not satisfactory from a chemical standpoint, and in numerous instances, bacterially unsafe for domestic use. Criticism on the quality of the water whether it be as to taste, odor or color, imaginary or otherwise, is more quickly expressed, and greater care is being exercised by the water company and the municipality to guard against such criticisms, which may have far-reaching and harmful effects on controlling interests.

It is thus needless to say that the development in the purification of water has passed beyond the stage where it can be entirely entrusted with safety to operators with but superficial training, and lacking sufficient education and interest to understand and reason. Not only are numerous periodicals, papers and articles written on the treatment of water, but meetings like this, for the discussion of problems confronting the operator, are held by many of the states, fostered generally by the State Department of Health.

Few Plants Free From Problems.—Even with the advance made in the treatment of water, there are comparatively few plants that are not confronted at times with some complexing problem, whether the water is derived from an acid laden stream, an upland impounded or underground supply. Irrespective of whether it is taste or odor from microscopic organisms, mineral constituents or organic matter, formations, decaying vegetable matter or color derived from certain geologic or industrial wastes, or whether due to operation, such as air-binding of the filters or imperfect filtration, the operator or chemist in charge must be able to ferret out without delay the cause and be able to remedy the same. There are cases where problems unexpectedly arise, not heretofore experienced, and it is found that correction cannot always be had by some particular treatment found successful at other plants. Different waters usually require different preparation and treatment.

Preparation of Water Important.—Much of the trouble generally experienced in operation is due to the lack of knowledge by operators in satisfactorily preparing the water for filtration. Success of any plant depends a great deal on the arrangement and efficient operation of settling basins. The elements of time, temperature, hydrogen-ion concentration and agitation are determining factors in the effective coagulation and settling of water. The period which is required to bring about the proper degree of coagulation varies with different waters, and authorities claim that this is caused, aside from those elements just mentioned, by the kind and amount of salts in solution, the character of suspended colloids, and by the amount of chemicals applied. Complete flocculation may take place in from 10 to 20 minutes, while with some waters, it may not be effected at the end of four hours. This especially may be true of waters low in alkalinity and turbidity. It is customary to refer to the time of settling as the period corresponding to the duration of flow or displacement of water in the basin, however, such a period generally is not obtainable, and the water passes through in considerably less time.

Velocities are affected by baffling, temperature and air conditions. After a proper coagulating of the water has taken place, the water must be subjected to as little agitation as possible, as a state of quiescence is necessary to bring about the greatest degree of deposition of settleable matter. When the turbidity is high, the chemical dosage should be so apportioned that the greatest reduction of suspended matter possible is obtainable in the basin, the aim being to effect the most economical and efficient coordination between basin and filters. An attempt should be made to remove enough of the suspended matter, so that, in the applied water, the turbidity does not exceed 75 parts per million, better still 25 to 35 parts per million.

The Jar Test.—Where a water is found difficult to coagulate, or to remove color, preliminary experiments by means of the "jar test" should be made to determine the amount of chemicals necessary for the efficient treatment of the water, and the time required for satisfactory coagulation and subsidence. Although this is familiar to many, it possibly may be new and useful to others. Prepare a stock solution of alum, lime or soda ash, whichever used, by adding 1.714 grammes of the chemical to 200 cubic centimeters of distilled water, so that 1 cubic centimeter of the solution applied to 500 cubic centimeters of the sample in a white glass cylinder or bottle is equivalent to 1 grain of the coagulant or alkali added. Thoroughly agitate by a general stirring, and note the time and character of floc formed, as well as period for subsidence of the coagulated and suspended matter. A series of these tests will indicate the minimum dose of chemicals necessary.

Valuable information also can be had, and used at most plants to successful advantage in the preparation of the water, by knowing the optimum point of coagulation as determined by the hydrogen-ion concentration. Having once determined the optimum pH, it is merely necessary to collect samples of the water from the mixing chamber and determine its pH. This may range anywhere from 4.5 to 7.5, but usually is in the neighborhood of 6.9. In the case where sulphate of iron is used in conjunction with hydrate of lime, it usually will be found necessary to carry the pH value considerably higher, in order to produce a good coagulation, and maintain a water free of corrosive action.

Where artificial alkalinity is being employed, extreme care must be taken, especially with some waters, to avoid the settling of organic color or the production of a milky effluent, by the use of too large an amount of lime. Provided color is a factor, and it is necessary owing to a low alkalinity and relatively high CO_2 content to use an alkali, hydrated lime is more satisfactory than the use of soda ash.

Red Water Troubles.—Should red water troubles be caused by too high a free CO_2 in the final water, experience has shown that it should not be completely absorbed by increasing the alkali in the settled water, but rather by aeration or reduction in the clear water basin. In a number of our plants where lime is used, we endeavor to carry a slight amount of free CO_2 in the applied water, and to produce a phenolphthalein alkalinity of from 0.5 to 2 parts per million in the final water by secondary treatment with an alkali in the clear water basin.

In some of our plants in the past, trouble has been experienced in properly clarifying the water due to the limited capacity of the settling basins, especially where the turbidity was exceedingly high and considerable sediment had accumulated. Where these conditions have occurred we have found it advisable to install a blow-out system in order that the mud and sediment can be syphoned out from all parts of the basin without putting it out of service. The operation does not involve any additional operating expense except the slight cost of the coagulant wasted with the flushed water.

The question of coagulation and its theory is very comprehensive and one with which most plant operators encounter more or less trouble but I have attempted in a general way to cover certain phases of this important feature of plant operation.

The Order and Taste Problem.—Another problem, equally as vexatious, is that of odors and tastes, and the clogging of the filter media due to certain forms of misroscopic organisms. Many of these organisms bring about rapid chemical changes in the water by exhausting the CO_2 content and reducing the bicarbonate alkalinity to normal carbonate alkalinity, as well as causing the water to become supersaturated with oxygen. Plant operators usually know from experience just about when these organisms put in an appearance and the time to start treatment to prevent their growth.

Where algae are present in large amounts, whether alive or dead, and reach the filters, the loss of head will build up rapidly and cause short filter runs. Combined with this, generally, is air-binding, which, until corrective measures are instituted, necessitates a short wash of about a minute to break the vaccum in the filter and liberate the air.

How Air Binding Was Eliminated.—A recent occurrence at one of our New Jersey plants demonstrates this clearly. The supply, which is derived from an impounded reservoir of some 170-million gallons capacity, is piped a distance of several miles, and thence lifted to a new 3-million gallon sedimentation basin. About a week prior to placing the basin in operation, the water, then being lifted directly to the filters, gave evidence of containing considerable algae. We had experienced this growth in the past, and for some years had treated the water successfully with chlorine as it entered an improved settling basin constructed at the lower end of the impounding reservoir. However, this year the algae appeared several weeks earlier than heretofore and before prechlorination had been started. The filters soon became clogged, necessitating from 40 to 60 washes a day. After washing, a run of from 60 to 80 minutes was had before the filters would again become air-bound, necessitating a breaking up of the media by means of a short wash. A microscopic examination of the water showed a number of forms of algae, the most numerous, and also one of the most troublesome in clogging filters, being the synedra of the diatoms. In addition to the chlorine applied at the impounding reservoir, a secondary treatment was given the water as it entered the settling basin.

Although the water was comparatively clear, and under normal conditions would have needed not over one-half grain of alumn for satisfactory coagulation, it was increased fourfold or about 2 grains per gallon in order to more rapidly settle out the organisms and prevent their being carried over onto the filters. With a heavy "floc" thus formed, the filters were then given a long wash and put back in service at a considerably slower rate. Within a day after this treatment, and change in method of filter operation, air troubles had been eliminated. The least amount of air getting into the under-drain system by way of leaky valves or controllers when the filters are operating under vacuum, tends to be liberated and to be entrapped in the voids in the filter media and results in air-binding. It is for this reason that an inspection of such filter appurtenances should be made periodically and remedial measures taken. It is also found at times that considerable air reaches the water through the raw water and wash water pumping units and chemical feed lines.

We have also found with algae growth in a sedimentation basin, where, due to the lack of turbidity in the water, it was somewhat difficult to get a heavy enough floc to carry down the organisms, that desired results could be had by the introduction of artificial turbidity by applying a solution of clay to the raw water. Fire clay, which precipitates readily with alum, can be applied either in suspension or fed through a dry feed machine.

The operators of plants which are troubled with algae or other similar microscopic organisms should be continuously on the lookout for these organisms during the season of growth, and should include in their laboratory control, a microscopic examination of the water, otherwise the first indication he may have of an increase in these plankton will be filter trouble, or increased color, taste, or odors in the water. The libraries of such plants by all means should contain a copy of Whipple's book on "The Microscopy of Drinking Water."

Maintenance of Filter Beds.—It is needless to say that extreme care must be taken in the maintenance of the filter beds, but how many of the operators actually do draw down the water every week or so in order to make an inspection of the sand. Once mud balls start to form, they are hard to eliminate, and unless taken care of their penetration becomes deeper, necessitating the removal of the sand and its cleaning or renewal. Mud ball formation is not due to the quality of the sand, but is caused by inefficient coagulation, or by an imperfect wash resulting from the failure of the washing system to expel and carry away the accumulation of mud lifted out of the bed by the wash water, or to a combination of both. Cracks in the sand indicate penetration of mud into the sand due, generally, to insufficient wash, while a crater of sand denotes a broken strainer or air line.

There are instances of both the over and under washing of filters. In the case of the former there is a chance, providing it is necessary to put the filter back into service under maximum rate, of carrying fine turbidity or coloring matter through the filter until after a "mat" has formed, thus reducing the bacterial efficiency of the unit. In the case of under washing, mud ball formation is bound to occur. The filters can be kept in better condition with less wash water and provide for a more uniform bacterial reduction by stopping the wash when there is evidence of clearing in the wash water. One cannot too often call attention to the inadvisability of rapidly opening either the wash water or effluent valves. This practice often is the cause of loosening the strainers, the blowing out of the sand, or the breaking through of the surface with the production of inferior water.

There are many other troubles which the filter plant operator experiences from time to time, but it is impossible to cover them all in a paper of this nature. In concluding let me say that every water purification plant should be operated under careful supervision and laboratory control. Do not wait until forseen trouble arises before measures are adopted to correct it. Be two steps ahead and prevent its occurrence. No matter what type or design of plant you have, it must be properly maintained and well operated to insure satisfactory results. No water company or municipality may with security ignore the necessity of producing at all times a pure and potable water supply.

Acknowledgment.—The foregoing is a paper presented at the last annual meeting of the Pennsylvania Water Works Operators' Association.

Meeting of New England Sewage Works Association.—The Spring Meeting of the New England Sewage Works Association will be held in conjunction with the meeting of the New England Health Institute, April 15 and 16, 1930, at the Hotel Statler in Boston.

The Water Cycle Between the Ocean, Atmosphere and Land

A General Survey of Some of the Outstanding Points in the Sciences of Physical Oceanography and Meteorology Showing Their Relation to Practical Problems of Water Supply

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The program of the water supply section of the school of citizenship and public administration in the Short Course last year at the University of Southern California was arranged to give the broadest and most fundamental treatment of the subject of water supply. Inclusion of "Oceanography" in the program is a specific illustration of the attitude which accords with the generally accepted principle that applied science, hydraulic engineering, for example, is based upon investigations in pure science in which scientific curiosity, or the understanding of nature, is the incentive. In his paper, which is reprinted below, Professor McEwen discussed the science of physical oceanography and the closely related one of meteorology with the purpose of showing their relation to practical problems of water supply.

BEFORE considering the water cycle, I shall define briefly the words ocean and oceanography. The word ocean denotes that great connected sheet of water which covers the earth's surface. Oceanography is the science that would deal exhaustively with the ocean, and is therefore a large part of the essentially composite science of geography, whose subject matter is, for convenience, classified with reference to the three geospheres, the atmosphere, the lithosphere and finally the hydrosphere, which includes all of the water, both on the ocean's surface and in the atmosphere. The ocean is therefore less than the hydrosphere.

Physical oceanography is essentially a composite science, and as applied to the ocean waters includes, first, the accurate measurement, throughout the ocean, of the physical and chemical properties of the water, such as its temperature, motion, salinity, gas content and acidity, and second, the precise formulation of problems suggested by these data and the corresponding meteorological and astronomical data, with the purpose of coordinating and interpreting this objective information and thereby discovering the corresponding laws of these phenomena.

Occurrence and Average Distribution of Water.—First consider briefly the occurrence and distribution of water in the sea, the atmosphere, over the earth's surface, and within the geological strata. Some idea of the amount of water in the ocean is suggested by the fact that the salt if separated from the water would form a layer of nearly 50 yd. deep over the whole surface of the earth. The volume of water in the sea is eleven times that of all land above sea level and is approximately three hundred and twenty-seven million cubic miles or one eight-hundredth that of the earth. While water occurs mainly in the ocean it permeates the atmosphere in the form of vapor, clouds and fog. In addition to its visible occurrence in lakes and reservoirs, large amounts are distributed throughout the soil even down to a depth of thousands of feet in some regions. Using the volume of water in the ocean as a convenient unit a general idea of the average amount of water distributed in these various ways is presented by the following table:

Volume of water in the ocean	1.00
Volume of water in the soil (ground water)	0.005
Volume of water in all inland seas and lakes	0.00009
Volume of water in the atmosphere	0.000009

While the estimates give an idea of the average distribution of water the condition is not static. From exposed water and land surfaces water continually evaporates into the air, where it exists in the form of vapor, and is carried in accordance with the atmospheric circulation to be condensed into fogs or clouds, from which a part is precipitated as rain or snow. After precipitation a large proportion returns to the original source, the ocean thus completing the water cycle of transformation and transportation.

Transportation of Water Vapor from Ocean to Land.—In considering some of the details of the different processes that constitute the water cycle I shall begin with the atmosphere and deal mainly with the North Pacific region. Averaging many thousand observations of wind and barometric pressures indicates a "high" pressure area about a thousand miles west of San Francisco and a "low" pressure area over the Aleutian region. Winds blow out spirally from the "high" in a clockwise direction and blow in spirally toward the "low" in a counterclockwise direction. The "high" moves northward and farther from the coast in summer. It also increases in intensity and area and the prevailing winds become steadier and stronger. The "low" is especially well developed in winter and disappears in summer. South of the equator the winds are counterclockwise about a "low" and clockwise about a "high." A chart of the winds indicates a line of "convergence" (a line toward which air flows from both sides usually accompanied by a flow parallel to the line) between the "high" and "low" directed toward Vancouver in the winter and Central Alaska in summer. An equatorial line of convergence in the doldrum region is equally prominent. This is between the two oppositely circulating whirls about the "highs" of the North and South Pacific. The whole system is subject to a seasonal shift of several hundred miles to the north in summer and the south in winter of the northern hemisphere. Along both the North and South Pacific coasts of America is a large cold water area between the "high" and the coast and extending toward the equator. These areas are especially cold and extensive when the "highs" and their accompanying winds reach their greatest development.

Certain outstanding characteristics of the precipitation of the coastal region will now be considered in relation to these atmospheric and oceanic conditions. As a general rule on-shore winds are accompanied by precipitation, while off-shore winds are dry. Polar winds are dry, and winds blowing from lower latitudes into higher bring much moisture. Lines of "convergence" have abundant rainfall.

The Pacific Coast State of Colombia, South America, has rain at all seasons and is in the doldrum line of convergence. Farther northwards, along the coast from Panama to Guatemala, about 90 per cent of the precipitation falls during the six months from May to October. The northern Mexican frontier located in the off-shore trade-wind region is practically arid throughout the year, and north of this region extending as far as Vancouver Island the winter is the rainy season, corresponding to the changes in the "high"

and "low." The coasts of British Columbia and Southern Alaska have much rain throughout the year but most falls in winter when the frequency of cyclonic storms is greatest.

In addition to these regular seasonal variations there are differences from year to year. Occasionally very great departures occur and can be explained by corresponding changes in the ocean. A striking example of direct ocean influence upon coastal weather is afforded by the westward deflection of the Humboldt current in 1925, which permitted the warm equatorial waters to penetrate southwards along the coast of South America. This unusual development of the warm counter current, El Nino, resulted in abnormally heavy rains along the arid coasts of Ecuador, Peru and Chile. At the same time there was a corresponding deviation of the cold Benguela current, thus permitting the warm waters of the Guinea current to penetrate southward along the west coast of Africa where torrential rains resulted along that arid coast. There is some evidence of a recurrence of a similar phenomenon about every thirty-five years.

Conditions Essential to Precipitation.—On the average there are about five parts of water vapor per thousand parts of air by weight, and the higher the temperature the greater is the possible amount of water vapor. This invisible vapor when cooled sufficiently condenses, forming fogs or clouds. Minute particles, ions, dust, etc., which are widely distributed throughout the atmosphere, act as nuclei which greatly facilitate this condensation. The densest clouds contain about five grams of water per cubic meter of air. An average amount would be near one gram of water per cubic meter of air or about one part in a thousand by weight. The individual water particles are about 0.03 mm. in diameter. Further cooling is necessary to produce precipitation, the drops of water being as much as two or three millimeters in diameter. Accordingly, conditions essential to precipitation are primarily conditions that cool the atmosphere, which is a mixture of air and water vapor. This cooling may be brought about by mixture with relatively cold air, by a flow towards regions of higher latitude where a relatively lower temperature prevails, or by rising and expanding as the pressure decreases. In the atmosphere the latter process of "adiabitic expansion" is by far the most important cooling agency, producing clouds and precipitation. Accordingly, it is important to study the conditions that cause a rapid rise of air.

Orographic and Cyclonic Rain, and the Polar Front Theory of Storms.—A very good example of certain rain producing conditions is afforded by the warm, moist ocean winds blowing to the northwest from the Indian Ocean and turning to the northeast across the Arabian Sea and the Bay of Bengal during the northern summer. Wherever these monsoon winds, which have passed over a warm ocean path some 4,000 miles in length and are saturated with moisture at a relatively high temperature, are directed against steep slopes of coastal mountain chains in India there is heavy precipitation called orographic because of the topographic factor. The air is deflected upward along these slopes with sufficient velocity to produce a rapid fall in temperature. Where the winds descend over the warm land surface the air takes up any available moisture and precipitation is impossible.

If the air current is stable (density decreases at a greater than average rate as the height increases), as it is forced up a slope the surrounding air is lighter and thus ascent is resisted. The air will tend to flow out around obstacles rather than to continue upward. This explains why oftentimes the heaviest precipitation does not occur at the top of a mountain but at some intermediate elevation. Air warmed from below, as often happens in winter, when the air is colder than the sea, is unstable, and orographic rainfall is thereby aided. On the other hand, when air is cooled from below, as is often the case in summer over the cold inshore water belt of our California coast, a local fog or slight drizzle results, but orographic rain is hindered.

A different but very important condition producing a rapid updraft of air independently of local topography often develops at a surface of discontinuity, separating warm and cold air at the same level. By means of a very close network of stations in Norway, Professor Bjerknes found that warm winds converging toward colder winds rise above the colder air and their moisture is condensed in the same way as in the air rising up mountain slopes. There is convincing evidence that polar and equatorial air meet at a surface of discontinuity which intersects the surface of the earth and sea in a wavy-line extending entirely around the earth at about 50 deg. north latitude but departing hundreds of miles on either side of this average position. "Highs" and "lows" result from the separation of loops forming in this line of discontinuity or "polar front."

The weather of the northern hemisphere is a consequence of advances and retreats of this polar front which marks the frontier between masses of air of different origin. The expulsion of great masses of polar air, forming anti-cyclones, is an essential element in the general circulation. Warm air flows along the surface of the earth and sea from the subtropic "highs" toward the polar regions, concentrating in warm tongues and continuing into the polar regions at the upper levels where it cools and later reaches the lower levels. Thus masses of cooled air accumulate behind the polar front and cause it to advance southward. Finally, at places of least resistance great masses of cold air break through and are expelled in the direction of the tropics. This results in a northward retreat in the polar front, after which the process is repeated. Moreover, this intermittent quality of the general atmospheric circulation is especially characteristic of the winter season when marked discontinuities of sea surface temperatures prevail.

A succession of cyclonic storms then develops from alteration of the polar front, and they travel from west to east along tracks which appear as lines of convergence in charts of monthly averages. The structure of one of these cyclones is essentially as follows. There is a warm sector of less than a quarter of the total area and lying to the south, this air flows in a counter clockwise direction and is deflected upward over the cold air at the right (the observer is assumed to be facing to the north). The cold air also flows in a counter clockwise direction and forces the warm air upward at the left of the warm sector. Both of the boundaries of the warm sector are lines of convergence. According to hydrodynamic theory a line of convergence will move to the right of an observer looking along the line in the direction of flow. Thus there is an ascent of air at both of these lines and the cyclone moves from west to east. The spiral motion is due to the combined effect of the low pressure of the central area and the deflecting force due to the earth's rotation. There is in general an interchange of warm and cold air causing a transformation of potential into kinetic energy. Both the irregular and seasonal north and south displacement of the polar front result in a corresponding migration of the storm tracks, and the position and intensity of the North Pacific "high" determines how far south these cyclonic storms reach the North American coast. Finally, the sea temperatures due to the influence of latitude, evaporation, and the varying ocean currents are a fundamental control of the "highs." Thus we are led to regard the ocean and overlying atmosphere as parts of a complex mechanism driven by the sun's energy and obeying the laws of physics.

The Return Flow of Water from Land to Sea.—Precipitation varies greatly with respect to geographic location and with respect to time. It may be in the form of rain or snow. A combination of such a variety with a corresponding variety of topography, nature of soil, and growth of vegetation results in a great diversity of run-off. A part of the water collects in lakes or artificial reservoirs, some penetrates into the earth's surface, forming ground water, some is evaporated, and some flows directly into the sea. All of these conditions raise important problems in water supply engineering. I wish to emphasize the importance of

preserving a suitable vegetation cover to prevent erosion, which results in loss of arable soil and silting of storage reservoirs.

Owing to the interconnection of the oceans and the oceanic circulation the run-off becomes distributed over the whole surface of the sea. Thus we are led to consider the process of evaporation which completes the water cycle.

Evaporation from Water and Land Surfaces.—Although complementary to precipitation and of equal importance there is much less quantitative information about the rate of evaporation. This is due to the fact that while the measurement of precipitation is direct and readily made, evaporation must be determined indirectly from suitably made observations. For example, direct observations from a pan must be corrected by special methods in order to obtain the evaporation from a neighboring lake or reservoir. Although many investigators have worked on the problem of determining the rate of evaporation from lakes and reservoirs, owing to inherent difficulties and to lack of time to carry out a thorough rational investigation of suitable technic, discordant results have been reached. Empirical methods were used and there was neither general agreement as to the relation of pan evaporation to that of a large body of water nor as to the method of estimating it from meteorological data. Even less satisfactory information has been obtained about ocean evaporation, owing not only to certain observational difficulties not met with on land, but also to lack of a rational method of their interpretation. Available observations indicate a rate of about 2.7 ft. per year from the sea. There is also evaporation from the soil which under different conditions varies from about 20 per cent to 9 per cent of that from a water surface.

About ten years ago at the Scripps Institution, while working on problems of circulation and temperature distribution, I was handicapped by this meagre knowledge of ocean evaporation. The available results of evaporation investigations were either purely empirical and therefore of only local value, or theoretical but involving simplifying assumptions departing so widely from actual conditions in nature that the general conclusions could not be accepted. Even combinations of existing theoretical and empirical methods that proved very helpful in certain local engineering problems of water supply lacked the desired quality of being generally applicable.

In spite of the need of a clear understanding of the physics of evaporation long recognized by engineers, geologists, meteorologists and oceanographers, no investigation of the subject, leading to satisfactory results, had been carried out up to that time. Mr. Cummings, then assistant in physical oceanography at the Scripps Institution, undertook at my suggestion to make a critical study of the problem of evaporation. This investigation begun at the Scripps Institution led to cooperative work at the California Institute of Technology a few years later by Messrs. Cummings, Bowen, Richardson and Montgomery, to whom I am indebted for material which I have condensed into the following summary.

It is natural to regard evaporation from lakes as a process controlled by atmospheric conditions, such as air temperature, wind, and humidity. This view, then shared by Dr. Cummings, was not supported by an extensive statistical analysis which he made for the purpose of isolating the effects of various factors influencing evaporation. In particular, a very weak correlation was indicated between evaporation and humidity. He concluded that there must be a fundamental physical reason for this unexpected result.

Accordingly, it was decided to make a new beginning and attack the evaporation problem from the standpoint of the first law of thermodynamics. This investigation led him to formulate the following qualitative principle of evaporation analogous to the principle of Chatilier, in physical chemistry, and Lentz's law in electricity and magnetism. Any change in wind or humidity is always accompanied by a change in lake temperature which partially neutralizes the direct effect on the evaporation rate to be expected from the original change in atmospheric conditions, if the insolation remains constant.

The evaporation rate must evidently be determined entirely by energy, rendered available for that purpose in accordance with the equation

$$E=\frac{I-B-S-K-C}{L} \quad \ldots\ldots (1)$$

where (E) is the evaporation rate expressed in centimeters of depth, (I) is the incoming radiation per cm^2 of surface, (B) the back radiation to the sky, (S) the heat consumed in warming the water (or heat storage), (K) a correction due to heat transferred to or from the air as sensible heat, (C) a combined correction for leakage through the walls of the container, expansion of the water, and heat carried by flowing water. All quantities in the numerator are expressed in gram calories per square centimeter of open water surface and integrated over the time interval corresponding to (E). Let (R) be the ratio of sensible heat carried away by the wind and diffusing into the air to the latent heat carried off by the vapor. Then

$$LER=K \quad \ldots\ldots (2)$$

The ratio (R), although generally regarded as small, is not negligible, but available information was crude and limited. Thus the approximate equation used by Cummings to estimate evaporation from lakes,

$$E=\frac{I-B-S-C}{L(1+R)} \quad \ldots\ldots (5)$$

where (R) was neglected, suggested the need of a critical investigation of its value.

A theoretical attempt to relate the value of (R) to easily measurable quantities, and thus make possible an accurate estimate of evaporation from equation (5) was very successfully carried out by I. S. Bowen at the California Institute of Technology. His results, presented under the title "The Ratio of Heat Losses by Conduction and by Evaporation from any Water Surface," were published in the Physical Review, June, 1926, pages 779-787. For simplicity Bowen at first assumes diffusion coefficients, conductivities, and densities to be independent of temperature.

Then

$$m=D_1a(P_1-P_2)/L \quad \ldots\ldots (1)$$

is the mass of water vapor diffusing per unit time across a space of length (L), and area (a), where (P_1) and (P_2)

The Water Softening Plant of Miami, Fla.

are the densities of water vapor at the two faces of the space, and (D_1) is the diffusion coefficient of water vapor through the air. Multiplying both sides of equation (1) by the latent heat of vaporization (L), and denoting the energy per unit volume in the form of latent heat by (θ_1) and (θ_2), the energy (Q_L) carried across becomes

$$Q_L = D_1 a(\theta_1 - \theta_2)/L \quad \ldots\ldots (3)$$

The formula for that energy (Q_s) carried, by conduction, across the same space is

$$Q_s = Ca(T_1 - T_2)/L \quad \ldots\ldots (4)$$

where (C) is the conductivity of the air, and (T_1) and (T_2) are the temperatures of the two faces. But $C = D_2 C_p d$ where (D_2) is the "diffusion coefficient" or diffusivity for the heat energy, (C_p) is the specific heat at constant pressure, and (d) is the density of the air. Therefore the substitution of this value of (C) in (4) results in the equation

$$Q_s = D_2 a(Q_1 - Q_2)/L \quad \ldots\ldots (6)$$

where $Q_1 = T_1 C_p d$ and $Q_2 = T_2 C_p d$ are respectively the densities of specific heat energy at the two faces. The equations (3) and (6) for the transfer of latent and sensible heat respectively, are of the same form, and from kinetic theory (D_1) is only a few per cent greater than (D_2). Accordingly, heat losses by evaporation and diffusion, and conduction should follow the same laws and be affected in the same way by convection.

Suppose first, that the wind velocity has a constant value from the surface to a small height, (b), above the lake surface. If the lake is large and the velocity and height (b) are small, the layer of air from (O) to (b) will have its temperature changed to that of the water and will become saturated with water vapor. That is, its specific heat density will change from (Q_2) (value at windward side) to (Q_1), (value at water surface), and similarly its latent heat density will change from (θ_2) to (θ_1).

Therefore

$$R = \frac{Q_1 - Q_2}{\theta_1 - \theta_2} \quad \ldots\ldots (9)$$

since this is the ratio of the two kinds of energy taken on by each cubic centimeter of the air passing over the lake.

Next suppose there is no wind between the lake surface and the height (b). If the area of the lake is small and the velocity large, the water vapor and heat diffusing through the stationary layer from the lake surface to the height (b) will be carried away immediately and we can assume ($Q = Q_2$) and ($\theta = \theta_2$) at the layer at height (b). Under these conditions the rates at which heat and water vapor leave the water surface are determined solely by diffusion, and their ratio, found by dividing equation (6) by (3) is

$$R = \left(\frac{D_2}{D_1}\right)\left(\frac{Q_1 - Q_2}{\theta_1 - \theta_2}\right) \quad \ldots\ldots (10)$$

Case I represents a condition where the whole quantity of air under consideration is completely changed in temperature and moisture content to that of the layer of air in contact with the water. For this reason diffusion is not the limiting factor and hence the diffusion coefficients do not enter into the formula for the ratio of the heats lost by the two processes. It is obvious, however, that if conditions are such that diffusion does enter, it will be in such a way as to increase the loss by the process having the larger diffusion coefficient relative to the loss by the other method. Hence under any conditions of wind we may say, since $D_1 > D_2$ that

$$R \leq (Q_1 - Q_2)/(\theta_1 - \theta_2) \quad \ldots\ldots (15)$$

Case II, on the other hand, represents conditions where diffusion is the completely determining factor, the heat and water vapor being immediately carried away after diffusing through the stationary layer. If, however, these are not immediately carried away, they tend to build up the temperature and vapor density on the upper side of this layer, and thus decrease the gradient in the stationary layer. This in turn tends to slow down further diffusion. But the process with the larger diffusion coefficient will build up faster, and hence will be retarded more than the one with the lower diffusion coefficient. Hence we can write

$$R \geq D_2(Q_1 - Q_2)/D_1(\theta_1 - \theta_2) \quad \ldots\ldots (16)$$

Also, a pair of differential equations derived from the basic assumptions, and valid for all points above a lake, was solved, assuming the wind velocity to be proportional to any positive power (n) of the distance above the surface. This led to the result

$$R = \frac{Q_s}{Q_L} = \left(\frac{D_2}{D_1}\right)^{\frac{n+1}{n+2}} \left(\frac{Q_1 - Q_2}{\theta_1 - \theta_2}\right) \quad \ldots\ldots (14)$$

Making use of well known relations of (D_1), (C_1), and (P) to temperature, Bowen found that equations (9) and (10) reduced respectively to

$$R = .501 \left(\frac{T_w - T_a}{P_w - P_a}\right) \frac{P}{760} \quad \ldots\ldots (22)$$

and

$$R = .442 \left(\frac{T_w - T_a}{P_w - P_a}\right) \frac{P}{760} \quad \ldots\ldots (23)$$

which he replaced by

$$R = .46 \left(\frac{T_w - T_a}{P_w - P_a}\right) \frac{P}{760} \quad \ldots\ldots (24)$$

since the general solution indicates that, under ordinary conditions the value of (R) is nearer to that given by equation (23) than by equation (22).

T_a = temperature of the air.
T_w = temperature of the water.
P = pressure of the air in mm.
P_a = the partial pressure of water vapor in mm.
P_w = the partial pressure of water vapor if the air were saturated and had the temperature of the water surface.

Bowen's theory, relating (R) to readily measurable quantities, thus provides the information needed to render Cumming's equation (5) exact. However, the importance of being able to estimate (R) renders independent tests of Bowen's theory highly desirable, in order to establish its validity and discover its limitations. Cummings and Richardson undertook to test the theory by experiments involving the comparison between a small insulated evaporating pan and large tanks.

Empirical estimates of lake evaporation based upon pan observations are subject to error since water in pans of different sizes is known to evaporate at different rates. There was no general agreement as to the proper method of reducing pan evaporation to lake evaporation.

Solving equation (5) for (I — B) results in

$$H = I - B = S + LE(1 + R) + C \quad \ldots\ldots (4')$$

where (H) is called the heat budget per square centimeter of surface. (I) must be the same for all water surfaces exposed to the same external conditions, but (B) varies with the surface temperature, and is therefore in general different for different bodies of water. Using subscripts (1) and (2) for the pan and the other body of water respectively, and remembering the equality of (I_1) and (I_2) results in the equation

$$B_1 - B_2 + S_1 + LE_1(1 + R_1) + C_1 = S_2 + LE_2(1 + R_2) + C_2 \quad \ldots\ldots (5')$$

The difference in temperature found between the two water surfaces being less than 15° C. in his experiments, Stefan's law of black body radiation gives ($T_1 - T_2$) (.5) as the value of ($B_1 - B_2$) in calories per sq. cm, per hour. Therefore since all quantities in equation (5) can be directly measured it can serve to test Bowen's theory under any desired conditions. Moreover, if the theory is correct, and the evaporation (E_2) from one body, a lake for example, can not be measured equation (5') can be used to compute it. Cummings and Richardson have published the results of their experimental tests of equation (5') under the title "Evaporation from Lakes" in the Physical Review for October, 1927, pages 527-534.

The dimensions of the containers used as as follows:

	Pan	Tank Pasadena	Tank at Fort Collins
Area	0.37	2.2	520. sq. m.
Depth of vessel	.19	1.47	2.0 m.
Depth of water below rim	.01	.02	.07

The tank at Fort Collins was so large that insulation was unnecessary. Both of the other containers were insulated and corrections were made for

the small leakage. Many comparative runs were made under quite dissimilar circumstances. A remarkably close agreement was found between the two members of equation (5′), thus proving Bowen's method of determining (R) to be a high precision under field conditions. Therefore the evaporation from a lake can be computed by determining (H_1) from pan observations near the lake and applying the ($B_1 - B$) correction for estimating (H), the heat budget of the lake and substituting in the equation

$$E = \frac{(H - S - C)}{L(1 + R)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

where (S), (R), and (C) are determined for the lake.

This research is more than a comparison of evaporation from two containers of different dimensions, since if any technique is ever developed for measuring (H), then lake evaporation can be found without using a pan or measuring wind velocity. The procedure outlined can be used to measure lake evaporation with satisfactory precision, and reliability, and although like most primary standards it is difficult to apply it should aid in developing methods more readily applicable in case great accuracy is not required.

Evidently it is important to make many field tests of the value of (R) under dissimiliar conditions, and thus provide general information regarding the probable value of this correction.

This procedure measures by means of a pan, the amount of energy available for dissipation by the larger body of water in the items of evaporation convection and sensible heat, but does not enable the absolute amount of energy reaching the water surface to be computed. Only the back radiation difference between the pan and tank has thus been considered. A later detailed consideration by Richardson and Montgomery of the radiation-exchange between the water and the atmosphere indicated that the effective radiation from a water-surface could be accurately represented by the equation

$$B = aT_w^4 - baT_a^4$$

where (T_w) and (T_a) are respectively the absolute temperatures of the water and the air above it, (b) is a factor (approximately = 0.9) which corrects for the fact that the atmosphere does not radiate as a perfectly black body. Accordingly, the incoming radiation from the sun and sky per square centimeter of surface, corrected for reflection, can be computed from pan observations from the equation

$$I = S + LE(1 + R) + B + C$$

Comparisons of values of (I) computed from this equation with pyrheliometer readings indicated a departure of but 4 per cent. Accordingly, the evaporation from an exposed body of water computed from the equation

$$E = \left\{ I - aT_w^4 + baT_a^4 \right\} \div L(1 + R)$$

will be subjected to a small relative error of about 4 per cent where either pan or pyrheliometric observations are used for estimating the available solar and sky radiation denoted by (I).

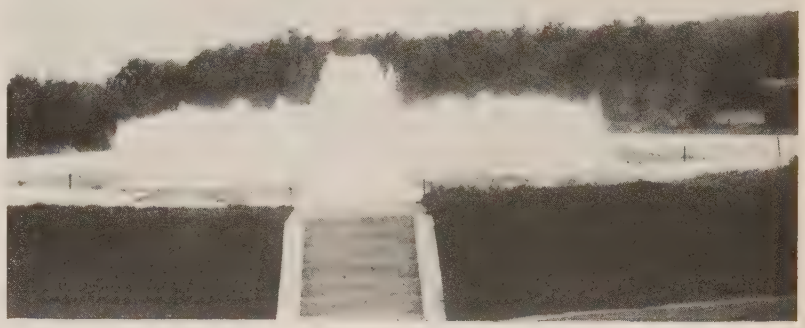
During the progress of these investigations which, except for observations of the total amount of heat in the body of water, were concerned with conditions in the air above the water surface, I was attacking the problem from a different angle. However, all of the work was based upon energy changes. My results are presented in a Scripps Institution technical bulletin being printed by the University of California Press, under the title:

A Mathematical Theory of the Vertical Distribution of Temperature and Salinity in Water under the Action of Radiation, Conduction, Evaporation, and Mixing Due to the Resulting Convection: Derivation of a General Theory, and Illustrative Numerical Applications to a Tank, a Lake, and a Region of the North Pacific Ocean.

The following brief statement is based upon this publication. Oceanic circulation involving a general flow either vertical or horizontal causes corresponding changes in the distribution of temperature and salinity. For example, investigations of the California coastal region indicated marked changes of this kind. In attempting to work out quantitative relations between circulation and the accompanying temperature changes it was found necessary to determine the "normal" distribution of temperature and salinity. That is, it became necessary to develop a physical theory of the absorption of solar radiation, back radiation from the surface, conduction of heat through the air, heat loss due to surface evaporation and the transfer of heat and other properties of the water by the alternating motion of water, especially from one level to another.

This general problem pertains not only to the ocean but to all exposed bodies of water. My treatment of it assumes that the time rate of change of temperature at any given level in a lake may be regarded as an effect of four groups of causes.

First, heat is added by the absorption of solar radiation, a process which can be neglected except at depths within the region extending only a few meters below the surface.



The Influent Aerator at the Water Filtration Plant of Providence, R. I.

Second, heat is transferred within the lake from one level to another, by means of eddy motion or turbulence in a manner agreeing, formally with the law of heat conduction in solids.

Third, because of winds or horizontal gradients of specific gravity there may be a general drift or flow of the water, resulting in an accompanying transfer of heat.

Fourth, heat is removed from the water surface by evaporation, back radiation and conduction through the air. The resulting increase of specific gravity of a thin surface layer of the water causes a settling of relatively heavy and cool masses of surface water, compensated by a rise of relatively warm and lighter water.

All but the fourth group of causes have been extensively investigated, and a theory of this diffusion of surface heat loss downward can be developed as follows:

Assume that surface water masses tend to remain at that level, and consequently do not descend unless adequate forces are present. General experience relative to the variability of conditions in open bodies of water such as lakes, suggests that at different positions on the surface the forces required to cause the water masses to descend will be different. Accordingly, in the absence of detailed knowledge a normal frequency distribution of density departures is assumed, and the rate of settling of each small water mass at any level is assumed to be

proportional to the difference between its specific gravity and that of the surrounding water. Thus water masses whose specific gravity and corresponding temperature vary through a certain range fall to different levels, and the surrounding water rises. Furthermore continuity of mass requires an equality of upward and downward flow at each level.

Using this basis the problem was formulated by attempting to devise a mechanism whose behavior could be worked out mathematically. By a process of fitting the resulting equations to observations of temperature and salinity from the surface to a depth not exceeding 100 meters even in the ocean, and repeated at regular time intervals, the physical constants can be computed corresponding to each time interval. These computations furnish theoretical estimates of the rate at which solar radiation penetrates the surface, the rate of surface cooling. Thus by applying the Bowen ratio and back radiation correction used by Cummings and Richardson, an estimate of evaporation is provided without the use of the pan. Furthermore, by applying the same mechanism of downward diffusion to the distribution of salinity and combining the resulting equations with those pertaining to temperature a method has been worked out for estimating separately the surface cooling due to evaporation and to other causes. This method is independent of all observations except serial temperatures and salinities and is theoretically adequate for estimating evaporation from the ocean.

While a good deal of information has been obtained regarding the water cycle there are many deficiencies as to detail and there is room for much progress in theoretical studies carried on for the purpose of understanding the physical laws and interpreting the observations. Moreover, we have the fundamental instrumental designs and theoretical technic for making quantitative estimates of the elements composing the water cycle, but there is need of applying them to an extent commensurate with the importance of this vital world-wide phenomenon.

New Jersey Proposes $7,000,000 Bond Issue for Water Supply Protection.—A bill has been introduced in the State Legislature of New Jersey providing for the issuance of $7,000,000 of bonds by the state for the protection of potable waters. To become effective under provisions of the constitution, the measure would have to be ratified by the voters. If passed, the referendum would be a part of the November election. The purpose of the bill is to provide for costs of acquiring lands, water rights and other interests for the protection of potable waters in the state.

Boom Activities in Engineering Construction Predicted

The outlook for construction activity in 1930 is gradually taking definite shape, according to E. J. Harding, assistant general manager of the Associated General Contractors of America. "Our statistical data now indicates boom activities in highway, public improvement and all other classes of engineering construction," he states. "The first indication of an acceleration of building activity is now at hand and relates to non-residential construction. Prospects for residential work are still indefinite with no specific indications of revival yet at hand."

The favorable outlook for engineering construction is based on several indicators, according to Mr. Harding. The increased sale of state and municipal bond issues during December, 1929, and January, 1930, presents a combined total for such bond sales that has been exceeded but once by any similar combined total.

A further indicator is seen in the recent increase in federal aid appropriations for state highways, which increase of $50,000,000 annually should result, when matched with state money, in an increase of more than $100,000,000 for such work during 1930.

Reports on contemplated work as compiled by the F. W. Dodge Corporation show that engineering construction on the boards between Jan. 1 and Feb. 7 is 188 per cent greater in valuation than during the same period in 1929. These figures relate to projects being planned by engineers which have not reached the contract award stage.

Engineering construction contract awards for this year up to Feb. 7 show an increase over last year of 60 per cent. This is seen by the contractors' association as a tribute to the manner in which federal, state and local governmental agencies have expedited plans for construction in response to President Hoover's appeal after the stock market decline.

The first indication of an acceleration in private building operations is now visible in the reports of contemplated work in the non-residential field up to Feb. 7. These are 30 per cent greater in valuation than similar reports in 1929 and are seen as a very hopeful augury for the future.

A. W. W. A. Membership Campaign Off to Good Start

Five hundred new members before the St. Louis convention is the ambitious goal set by Arthur E. Gorman, chairman of the 1930 membership committee of the American Water Works Association.

The campaign in its first stage was launched three weeks ago with an appeals to the entire membership of A. W. W. A. for assistance in furnishing a list of "live" prospects. The returns were most encouraging and indicate a wide interest in the campaign by the members. To date 257 cards have been returned to the committee recommending 2,009 prospects for membership.

The drive is being organized in cooperation with the section offices and committees in the unorganized states. The following table shows the quota set by the membership committee and the prospect returns received to date:

Section	Quota	Prospects to Date	Ratio P/Q
California	25	121	4.7
Canada	30	142	4.7
Central States	40	241	6.0
Florida	15	35	2.3
Four States	55	143	2.6
Illinois	25	113	4.5
Indiana	20	26	1.3
Kentucky-Tennessee	20	62	3.1
Minnesota	12	33	2.8
Missouri Valley	30	142	4.7
Montana	6	33	5.5
New York	55	295	5.4
North Carolina	20	79	4.0
Pacific Northwest	15	26	1.7
Rocky Mountain	20	45	2.3
Southeastern	30	106	3.5
Wisconsin	10	82	8.2
Non-Organized States			
Foreign	5	19	4.0
Louisiana	5	25	5.0
Nevada	2	17	8.5
New England	25	106	4.2
Southwest (Texas, Oklahoma, Arkansas)	25	88	3.5
Virginia	10	30	3.0
Total	500	2,009	4.0

The campaign will be carried out along two major lines:

1. Personal solicitation.
2. Direct mail.

The direct mail campaign to prospects will consist of five mailings beginning the third week of March and concluding two weeks before the St. Louis convention. Through section committees it is planned to personally solicit every prospect on the list, the direct mail campaign being depended on to create interest in the association and assist in the membership drive.

Enthusiasm is running high at headquarters and among the various section and state committees everyone interested in A. W. W. A. is being called on to make this campaign a success State sanitary engineers, manufacturers' representatives, water works superintendents, consulting engineers, in fact everyone contacted with so far by the membership committee has agreed to assist in putting the drive over the top.

Every month a summary of the results of the drive will be published. Watch for results and put your shoulder to the wheel for 500 new members before the convention meets in St. Louis.

"Water Works Accounting and the Public"

An Outline of the Common, Everyday Problems of the Water Works Superintendent, and Notes on the Practice at Raton, N. Mex.

By G. C. CULBERSON
Manager, City Water Works of Raton, N. Mex.

IT is easy for water works men to become self-satisfied with their plants; to get into a rut, so to speak; satisfied with everything about us and just drifting with the tide. Now, the reason that I come to this convention from year to year is to gain knowledge that I do not have of the water business and then to go back home and put some of it into pratcice, consequently improving our water system. I do not consider that my board makes a better investment during the year than the money expended for my expenses to this convention.

Accounting Systems.—There are many systems of general accounting in the water business; and some are worse than others. It is difficult, of course, to fit any one accounting system to every project, some plants being privately owned and some municipally owned. But for all purposes I think the Uniform Classification of Accounts, as prescribed by the National Association of Railway and Utility Commissioners, comes nearer meeting the needs of the average plant than any I have seen. And remember, too, there are still many that I have not seen. That system is capable of being expanded to meet the needs of the larger plants. I think it has less "bunk" and superfluous stuff in it than any I know of.

I have no "ax to grind" for any accounting system in particular, but I am fearful that many of us do not know where we are; and what I want to say is that we should know absolutely, as we are entitled to. Do you know if your plant is self-sustaining? Is it making money or losing money? These are vitally important questions for our consideration.

If your plant is a municipally-owned one, it is a separate entity and does it have a distinct and a separate set of books of account? Too often the case is that the water business is dumped in with all of the other activities of the city and consequently nobody knows what it's all about. That, in my opinion, is altogether wrong. As manager or superintendent you are entitled to know. If everthing in the way of revenue is in one pot how are we to know if our rate structure is too low or too high. Mr. Tax-Payer may be the goat for such blunders; he generally is. If you have dog tax and paving tax and water revenue all thrown in together it is utterly impossible to analyze your costs with any degree of accuracy. Let us insist that we have a separate set of accounts so that we may know if our efforts over a given period have been properly and profitably directed. Of course, if you have a privately-owned plant, this phase of this paper is of no interest to you.

Audits.—Another general proposition is the accounting end of our work. Do you have an annual or semi-annual audit? I think this is one of the best topics we water men can take. It is not only good for water men but it is good for any kind of business. We might have become ever so proficient as managers and superintendents, and the employes we have under us might be ever so capable, but an audit will clarify the atmosphere between your department and the public. And in many cases it will reveal errors that have been expensive. Sometimes we might be charging into operating expense items that properly belong in our capital accounts. Or we might be charging off as uncollectible bills too many accounts that should have been collected. And so on. There are numerous defects that an audit will bring to the surface.

Some will say, "well, an audit costs too much money." All things being equal I think it brings greater returns than any money expended. The influence of an audit is beneficial, even if no errors are found and no money recovered; the fact that all concerned know that an audit will be made periodically is worth more than the dollars and cents value.

Some will say, "well, I don't think we need an audit." In the majority of cases that is the fellow that needs an audit. Sometimes we dislike the idea of having a doctor with us because we are afraid he will tell us what is wrong with us. That is the time we need the doctor, and so it goes with the audit.

You may say this has no bearing on the accounting subject. Yes it has. Periodical audits will be helpful in getting modern methods installed and things properly systematized. Let us have audits in the water business. It seems to me that it helps somewhat to dignify the business we are in, and puts it on a higher plane.

The Raton Plan.—In developing some further points I want to refer to the way we do some things down at Raton, N. Mex. However, I hope you will not get the impression that we think our plant is beyond improvement. We have plenty of room for improvement; that is one reason I am here at this convention—in quest of new ideas and practices.

Our plant is municipally owned. Our population is about 7,000, and we have 1,630 water taps. Our taps are 99 per cent metered. It is a gravity system, the impounding reservoirs being some 10 miles from the city.

A board, created some years ago by city ordinance, known as the Board of Public Works, administers the affairs of our water department. Four men constitute this board, two from each of the major political parties. (We have only two brands of politics down there, republicans and democrats.) These men are appointed for terms of four years each, one term expiring each year. (Our city elections are every two years.) Board managers draw $100 per year salary. The board appoints a manager and he has charge of operations. The board meets one time every month and more if necessary. Monthly reports are made to the city, and a copy of the annual audit goes to it at the end of the fiscal year.

Sinking Fund.—Our bond issue is being retired annually from a sinking fund created by a tax levy. There is room for argument and discussion at this point. Our laws in New Mexico make this an optional point. We can retire bonds either with water revenue or tax money. My personal opinion is that perhaps the better plan is to retire bonds with water revenue. This is the only place where there is any interlocking of the accounting system as between the city proper and the water department.

The question I raise is this: Do you have a bond issue and are you putting money from any source into a sinking fund with which to retire the bonds. This is an important question. If you answer in the affirmative, well and good. If not, let me urge you to make such provision within a reasonable time after date of issue.

Reserve.—Every water plant should have a reserve, and not simply a book proposition, but a cash reserve or the equivalent thereof. The character of the water business with the emergencies that arise at flood periods often calling for an outlay of capital, demands that available funds should be provided. Such funds will be created only if your rate structure is at the proper level and cost of operations properly supervised.

It is advisable to invest such funds in approved securities and allow inter-

est therefrom to go back into and build up the reserve.

As to the extent of such a cash reserve, or how much money should be accumulated in it, is difficult to say, as a rule. But I should think not less than from 7 to 10 per cent of the value of the fixed assets. When such an amount has been reserved good business judgment will dictate as to the lowering of rates.

Another important advantage in having a comfortable cash reserve is that it precludes the necessity of having to issue bonds every time any improvement or replacement of assets is to be made. Bond issues are fine for the bond houses and the brokers but they are extremely expensive on the taxpayers. Let us insist on building up a cash reserve, if we have not already started one.

The Public.—Getting down to the consumer: Our consumers' ledger is a loose leaf affair, with space for four years business on it; also, space for the tap number, address of owner and his name, name of tenant, lot, block, and addition description. We have found these to be very satisfactory.

There is, of course, a general ledger control account into which the value of the consumers ledger must tie. These are balanced with the control every month, in our office. Not semi-annually or quarterly, but monthly.

We deal with property owners, only, or their agents, and not with tenants as such. We have found this rule very satisfactory. If a property owner lives in California and wants a local man to be his agent we furnish him with a form of a contract, designating so and so as his agent. But the property owner is still responsible for water bills.

Under New Mexico laws liens may be filed for water bills; in other words the property stands for the bill. We do not resort to that law except in extreme cases.

Quarterly or Monthly Billing.—We bill the consumer quarterly. (More room for argument.) Briefly, we bill quarterly for the reason that it precludes the necessity for making out bills and reading meters twelve times each year as against four times. At the same time I appreciate the fact that a consumer will pay monthly, or small water bills, with more grace than he will a larger, or quarterly one. Some consumers say they prefer the quarterly bills so that one trip to the office to pay suffices for three months, and there you have it—take your choice. However, I believe in the majority of cases bills are rendered monthly.

Discount on Water Bills.—One of the most progressive steps taken in our department for years was the adoption some two years ago of a discount of 10 per cent, on water bills, if paid within 15 days after the end of the quarter. It has cured more ills than any one rule we have. The folks like it. We now have it in both the water office and the light office.

We had people, just as you have them, that we were forever and eternally hounding to pay their water bills. Not so now—and those were good people in our city; good citizens. I say it has created harmony and good feeling. It is a loud speaker for good will.

Good Will of the Public.—All of this naturally leads into a discussion of good will, one of the most invaluable assets: the good will of the consumer—it amounts to much. We should cultivate it. We as managers are to blame in no little degree for the attitude of the public toward our business.

People are the same the world over. They rebel at one thing, one lever, that we water men have. That of chopping of the water when the bill is not paid. An advantage which I think should be exercised with common sense and judgment. And it is so easy to just tell a consumer "Take it or leave it"—we'll cut your water off if you get fresh with us. That sort of an attitude toward the public will not only destroy any good will there might be but will utterly fail to get the confidence of the public. Courtesy at the counter or window will go far toward creating and cultivating good will. A smile at the proper time is a good stimulus. A little time and patience with a consumer in trouble helps wonderfully. We should not forget that the average consumer knows almost nothing about what to do when something goes wrong with the water pipes and fixtures. Naturally, the first place he thinks to call up is the water office. That is the logical thing to do. Let us enjoy the confidence of the people and their good will just as other businesses do. We have the remedy in our own hands.

Big Water Bills.—What do you do when a consumer comes in with a water bill all out of proportions that he's "all het up" about—scared to death that he is going to be compelled to pay it. The meter has charged him up with enough water to start a good sized river. At this point is a good time to display some tact and common sense—the two words are synonymous. A little sympathy and patience will calm the consumer greatly, if he is a normal human being.

We, under such circumstances, go and make an investigation of his case—check up pipes and fixtures on his premises. If we find that he has a leak of which he knew nothing about, from some underground source, we simply propose to him that we will cut his bill in half (50 per cent reduction) on the condition that he have repairs made immediately and stop the waste of water. He, in the majority of cases, is delighted over the idea of not having to pay all of the bill, and settles it then and there, and goes out feeling like he got a square deal after all.

In checking up large bills care should be exercised, of course, and if he has had leaky faucets or fixtures of any kind common sense will tell you that the family had known of the leak; and in such a case there is only one thing to do—demand that the bill in full be paid.

In reading meters we have a plan whereby we pick up large readings and inform consumers either by phone or otherwise at once. They appreciate it. It is good psychology, too, because when time of settling the bill comes it is easier to get along with them.

Beautify Consumer's Premises.—Another thing that will promote good will and good feeling is to take part in contests to have the best kept lawn, flower garden, and shrubbery. It is remarkable how much a little paint, some water, fertilizer, and grass and flowers, will improve appearances of property. Affiliate with the local civic clubs and foster such a contest and let the water department offer one of the substantial prizes.

When we do such things we not only help the consumer but we help to beautify the city, property values are enhanced, and if the system is metered, all of the prize money and more will come back to us through revenue.

Acknowledgment.—The above is an abstract of a paper presented at the last annual meeting of the Rocky Mountain Section of the American Water Works Association.

Expense Ratios and Costs of Water Sold.—The following table taken from the 16th annual report (1928-1929) of the Pasadena, Calif., Water Department, S. B. Morris, Superintendent and Chief Engineer, shows the expense ratios and costs of water sold for the above period:

	Percentage of Water Revenues	Percentage of Total Expense	Cost of Water per 100 cu. ft. (in cents)
Source of water supply	4.05	2.28	0.35
Pumping expense	22.62	12.71	1.98
Purification expense	.34	.19	0.03
Water production	27.01	15.18	2.36
Distribution expense	8.88	4.99	.78
Commercial expense	9.43	5.30	0.82
General	12.52	7.03	1.09
Operation and maintenance	57.84	32.50	5.05
Depreciation	31.48	17.69	2.75
Interest	10.68	5.99	.93
Total	100.00	56.18	8.73

Water production total, 638,954,400 cu. ft.
Total water sales, 567,039,700 cu. ft.
Cost of water per 100 cu. ft., based on water sold.

Illinois Section A. W. W. A. to Meet at Chicago.—The annual meeting of the Illinois Section of the American Water Works Association will be held at the Stevens Hotel in Chicago, April 23-24, 1930. J. J. Doland, 317 Engineering Hall, Urbana, Ill., is secretary.

A Recent Development in Lime Water Softening

Improved Process Provides for Addition of Calcium Carbonate on Sludge Produced from Water Softening Reactions

By CHARLES P. HOOVER

Chemist in Charge, Water Softening and Purification Works, Columbus, Ohio

THIS process or development relates to a method of reducing carbonate hardness of water by lime softening to the theoretical or approximately to the theoretical limit, that is to the solubility limit or approximately to the solubility limit of calcium carbonate and magnesium hydroxide. The process comprises adding to the water sufficient lime (CaO or $Ca(OH)_2$) to combine with the free and half-bound carbon-dioxide and to precipitate the magnesium hydroxide. Considerable lime (25 to 50 parts per million) in excess of that theoretically required to replace the magnesium must be added in order to convert the magnesium salts in the water to magnesium hydroxide. This leaves excess lime or caustic alkalinity ($CA(OH)_2$) in the water. After partial settling the excess lime is neutralized with carbon-dioxide, then calcium carbonate, water softening sludge or other inert finely divided material is intimately mixed with the water after which it is clarified by settling or filtration.

What Water Softening Reactions Show.—Water softening reactions, as usually written, indicate and show that when hard water, containing bicarbonates of calcium and compounds of magnesium, is treated with lime for softening purposes, the highly soluble bicarbonate is converted to insoluble or only slightly soluble normal carbonate and that the magnesium is converted to magnesium hydroxide which is only slightly soluble.

Unfortunately, lime water softening reactions do not proceed in cold water or water at ordinary temperatures in an orderly fashion as represented by chemical equations. The precipitates of calcium carbonate and magnesium hydroxide are produced in a state or condition in which it is impossible to remove them by ordinary processes. Until very recently a 50 per cent average reduction of magnesium and an average reduction of carbonate hardness to 50 or 60 parts per million was considered as being as good as could be obtained. Many results running as high as 85 or 90 parts per million are recorded. During the first twenty years that the Columbus, O., plant was in operation, the alkalinity or carbonate hardness was reduced to an average of 50 parts per million, whereas theoretically it should have been reduced to some place between 15 and 20 parts per million.

Policy at the Columbus Plant.—Chemical handbooks usually record the solubility of calcium carbonate as being 13 to 20 parts per million and magnesium hydroxide as being 1 part per million, or in terms of calcium carbonate, 1.7 parts per million. These figures therefore represent the theoretical limit to which carbonate hardness can be reduced by lime softening. At the Columbus plant it has been the policy of the water department most of the time since the plant was started, to reduce the total hardness to about 85 parts per million or to 5 grains per gallon. Had the improved process, described in this paper, been available and been used during the past 20 years at Columbus, there would have been a saving of something more than $400,000 in the operating costs of the plant because more hardness would have been removed by lime and less with soda-ash, which is a more expensive softening chemical. Details showing how the $400,000 saving would have been made are given in the 1929 report of the Columbus Department of Water; they are reported by Chemist in Charge.

Data on Operation of Columbus Plant.—At this point it might be of interest to digress for a moment and show in tabular form some of the pertinent data regarding the 21 years of operation of the Columbus plant. These figures are taken from the 1929 water report and were prepared by Mr. C. B. Hoover, Superintendent.

Total gallons of water softened	162,496,000,000
Average per day	21,200,000
Hardness removed, parts per million	26,656,000
Or approximately in grains per gallon	1,600,000
Average hardness removed, parts per million	164
Or average hardness removed, grains per gallon	9.8
Cost of lime	$843,356.98
Average price of lime per ton	$7.60
Cost of soda-ash	$1,639,122.68
Average price of soda-ash per ton	$30.45
Total cost of all chemicals including lime, soda-ash, alum, chlorine and coke	$2,817,976.91
Average cost per year	$134,160.00

Records of operation show that each grain of lime added per gallon reduces the carbonate hardness approximately 12 parts per million and each grain per gallon of soda-ash reduces the non-carbonate hardness approximately 16 parts per million. These figures are corrected to allow for the increase in non-carbonate hardness due to alum treatment. Using the average price paid for lime and soda-ash at Columbus during the past 21 years and the parts of hardness reduced as a basis for computation, the results show:

Pounds of lime per part of carbonate hardness removed per million gallons	12.1
Cost of lime per part of carbonate hardness removed per million gallons, cents	4.6
Pounds of soda-ash per part of non-carbonate hardness removed per million gallons	8.7
Cost of soda-ash per part of non-carbonate hardness removed per million gallons, cents	13.2

Procedure for Reducing Carbonate Hardness.—During the past year at Columbus and for several years at Piqua, O., it has been possible to reduce carbonate hardness to a very satisfactory figure (an average of 30 parts per million for the year and an average of 25 parts per million for the last 4 months of the year was obtained at Columbus) by using the following procedure.*

(1) Use from 25 to 50 parts per million of lime in excess of that theoretically required to combine with the free and half-bound carbon-dioxide and to precipitate the magnesium;

(2) Settle out settable precipitates;

(3) Recarbonate with carbon-dioxide gas to the point where the total alkalinity minus two times the phenolphthalein alkalinity equals approximately 5; and

(4) Filter through sand filters.

The following are typical analyses of water from mixing tanks, settling basins and filters:

Water from Outlet of Mixing Tanks	Parts per Million
Total alkalinity	68
Phenolphthalein alkalinity	51
Caustic alkalinity	34
Water from Outlet of Settling Basins	
Total alkalinity	53
Phenolphthalein alkalinity	24
Caustic alkalinity	0
Filtered Water	
Total alkalinity	22
Phenolphthalein alkalinity	11
Caustic alkalinity	0

Low results are obtained even in freezing weather.

The process of recarbonation requires very close supervision, as the carbonate hardness is not reduced satisfactorily if the water is even slightly over or under-carbonated.

Effect of Filtration.—The filtration of this water through sand filters has a bad effect on them because the calcium and magnesium compounds crystallize onto the surface of the sand grains, covering them with an adherent coating which causes them to grow in size and finally to lose their effectiveness as a filter medium. The sand grains not only grow in size, but they also

*Reduction of Carbonate Hardness by Lime Softening to Theoretical Limit, Journal American Water Works Assn., Vol. 21, Sept., 1929.

cement themselves together, forming hard lumps in filters. Once or twice a year it is necessary to spade up those filters and crush all hard lumps, and after seven or eight years of service the filter must be rebuilt.

Outline of Latest Development.—In carrying out the latest development which has been briefly outlined in the first paragraph of this paper, the carbonate hardness is reduced to or practically to the theoretical limit as follows:

(1) Use from 25 to 50 parts per million of lime in excess of that theoretically required to combine with the free and half-bound carbon-dioxide and to precipitate the magnesium;

(2) Settle out settable precipitates (this is preferable but not necessarily essential);

(3) Neutralize excess lime with carbon-dioxide gas ($Ca(OH)_2+CO_2=CaCO_3$);

(4) Mix with large excess of calcium carbonate, sludge produced from water softening reactions or any other inert finely divided material;

(5) Settle; and

(6) Filter.

Results of Latest Method.—For example: A sample of Scioto River water having a carbonate hardness of 144 parts per million was mixed with 11 grains per gallon of quick lime and settled. The supernatant water showed the following results of analysis in parts per million.

Alkalinity to methyl orange	78
Alkalinity to phenolphthalein	61
Excess lime or caustic alkalinity	44

The sample was carbonated with carbon-dioxide gas and then analyzed as follows:

Alkalinity to methyl orange	60
Alkalinity to phenolphthalein	31
Excess lime or caustic alkalinity	2

Calcium carbonate was added (1,500 parts per million), stirred for less than one-half minute, allowed to settle and was filtered through filter paper and analyzed with the following results:

Alkalinity to methyl orange	15
Alkalinity to phenolphthalein	4
Excess lime or caustic alkalinity	0

The novel feature of the process is the addition of calcium carbonate or sludge produced from water softening reactions. The return of sludge has been practiced in water softening, but has never been regarded as of much value, because it is harmful rather than beneficial if water conditions are not right.

Our results indicate that return of sludge is beneficial in reducing the carbonate hardness to the theoretical limit, only when the bicarbonate of calcium has been changed to normal carbonate, the magnesium precipitated to magnesium hydroxide and the caustic or excess Ca $(OH)_2$ neutralized to carbonate. These conditions having been obtained, the sludge not only accelerates precipitation of the finely divided suspended matter but acts as a stabilizing agent as well.

The process is new. It has not yet been tried out on a plant scale.

Results of laboratory tests indicate, that it is going to be a practical process, that the close supervision needed by the present process to obtain uniform and desirable results will not be required, that it will dispense with filtration difficulties and produce water with perfect chemical balance.

Acknowledgment.—The foregoing is a paper presented Feb. 14 at the 8th annual Three Day School at the University of Kansas and 5th annual meeting of the Kansas Water Works Association.

Contractors' Performance Records Studied

Methods of inter-industry co-operation looking toward the elimination of conditions which have made for irresponsibility in the construction industry and the securing of improved surety bonding practices, were outlined at the recent convention of the Associated General Contractors of America meeting, when a report on the work of the bureau of contract information was laid before the delegates.

This bureau was established four months ago at the joint suggestion of the contractors, architects and public officials and is financed by the surety companies of the United States. Its function is to investigate the performance record, past reputation and work on hand of every general contractor in the country. Delegates were told that performance records and contract statements received from contractors in the short time since the bureau was established, have reached a total of well over 1,400. Verification reports have been received from engineers, architects and public officials with respect to 10,161 construction projects. Verifications received from financial institutions total 2,502, and those from manufacturers and distributors of equipment and materials number 8,604. The total received from all sources is given at over 24,000.

The bureau is investigating the performance record, reputation and work on hand of every general contractor in the United States, and questionnaires designed to secure the necessary information are being sent to each contractor. As soon as replies are received, the information given in the questionnaire is verified. Various sources of information are giving their co-operation, the report stated, and verification reports are being received from surety companies, public bodies, engineers, architects, financial houses, manufacturers, distributors and contract reporting agencies.

Meters

No one will take issue with the statement that a measured water is more just, more economical, and more scientific, to both buyer and seller, than any flat or fixed rate that can be devised.

It seems peculiar, however, that there are those who have no objections to buying goods or liquids by weight or measure, but object most strenuously to having the same system apply to water.

The majority of people believe in paying for what they get. To object to the use of a meter is substantially to prefer the methods of antiquity and to oppose modern methods, which years of study and experience have developed. The basis of charge is determined by the quantity furnished, and we believe that is the best and only way.

While no doubt the fact that our meterage as a system is nearing the hundred per cent mark is due to the recognition of water users that it is the only fair and equitable method of payments and shows that the justice of the system has carried its own appeal. We would like to class all metered consumers practically as employees of the Water Department, each serving as inspector on his own premises. If consumers would read their meters often, compare their daily or weekly consumption, leakage would be detected and unpleasant surprises in water charges would be prevented. The commercial and domestic consumption of course depends largely on the personal habits of the people of a community, and to a considerable extent the water used is an indication of the standard of living.

We advise all unmetered consumers to lose no time in having a meter installed. Your monthly statement will show a substantial reduction.—From the 1929 report of W. H. Lawrence, Superintendent of Water Works, Kalispel, Mont.

Central States Sewage Works Assocaition to Meet in June.—The annual meeting of the Central States Sewage Works Association will be held in Springfield, Ill., June 9 and 10.

Harry Ferguson, President of the Springfield Sanitary District and chief engineer of the State Division of Sanitary Engineering, Springfield, will handle local arrangements for the gathering. The program now being drafted will include one and one-half days of sessions, at which committee reports and lectures on various phases of sewage disposal problems will be heard. A half-day will be set aside for an inspection trip at the Springfield sewage disposal plant, north of the city.

A 5 ft. Cast Iron Pipe Outfall

Construction Features of the 3-Mile Long Deep Sea Sewage Outlet for Lynn, Mass.

THE city of Lynn, Mass., has completed recently the installation of a 15,300 ft. outlet sewer by means of which the sewage is discharged into the ocean. We are indebted to the March issue of the "U. S. Piper" for the following details.

Preliminary work was done in 1925, but actual construction was not begun until 1926. The outfall project was designed to meet the conditions estimated to occur in 1960, for a population of 170,000. As the two interceptors have a combined capacity at low tide of 60 m. g. d., pumping units for this flow have been provided. In periods of heavy storm, a provision has been made of permitting an overflow into the old outlet in such a way as to prevent this overflow from functioning in periods of small storm and normal flow.

Laying Section of Pipe with "Stiff-Back"

The outfall sewer proper extends from the pumping station near the present outlet, to a point about 3,600 ft. southwest of Bass Point, Nahant. The position of the outlet end was fixed so as to permit laying in as straight a line as possible with no rock excavation.

The material used in this sewer is cast iron pipe 60-in. in diameter. The line extends for 8,500 ft. across the flats with a cover of about 5 ft. The line then passes through a siphon under the federal ship channel for a distance of about 1,200 ft.

This allows a channel 500 ft. wide and 30 ft. deep. From the end of the siphon to the outlet, approximately 5,600 ft., the line is laid at a uniform gradient with about 3 ft. of cover. The actual outlet consists of a 60-in. 30 deg. bend pointing upward and suitably anchored with crushed rock and concrete slabs. Provision has been made for a future siphon in case the harbor development project is consummated.

Dredging the ditch was begun at the channel section and proceeded toward the outlet. A trench 10 ft. wide was dredged to hold the pipe, deep enough to provide the required cover. No rock was encountered so that excavating was not difficult. When the trench across the flats was formed, a channel deep enough to float the barges was dredged alongside the trench thus enabling the work to be carried independently of the tide.

Dredging the Trench

Dredging operations were closely followed by pile driving. Two piles were driven for each bent and two bents were made for each pipe. The piles were driven with a steam hammer and were from 12 to 30 ft. long. The bents were secured to the piles by ¾ in. bolts 18 in. long and were capped with 8x8 spruce timbers. The pipes rested on these timbers and were held in place by wedges nailed to the timber caps. In the places where piles could not be driven because of rock ledges, the bents were installed with built up footings.

The 60-in. pipe were delivered to the Sangus River yards of the Boston & Maine R. R. adjacent to the General Electric Co. River Works. A dock was constructed here by the contractor for loading the pipe onto the barges. The joints used were bell and spigot and four lengths of pipe constituted a section. Sections were made up on the barge and caulked with air hammers. When the barge was in position a "stiff-back" would be securely lashed to a section and the section lowered into place and the joint made up by divers. The cut shows the method by which the section was lowered.

Leakage tests were made after a few sections were laid and these tests were repeated as the laying progressed. Bulkheads were placed over both ends and a vacuum was established. The amount of water leaking in determined the leakage and when 80 per cent of the line had been completed, this leakage was but one-half that allowed by the specifications.

The laying of the outfall sewer was done by the Merritt-Chapman and Scott Corporation of New York City. Morris Knowles, Inc., of Pittsburgh were the Consulting Engineers, with Mr. M. G. Mansfield, Engineer-in-Charge and Mr. E. F. Twomey, Resident Engineer. The borings and soundings were made by B. F. Smith Co. of Boston.

Turbine Type Pump 864 Ft. Long

Water development for California's lucrative citrus crops has had much influence on the building of large pumps. Continued pumping from wells in various localities gradually lowered the subterranean water levels until water production meant lifting 400—or even 500 ft. to the surface. Early in 1929 a record was established when a deep well turbine pump was constructed and installed at Pomona, Calif. The total lifting head from below the ground was 540 ft. In this pump were incorporated many features which make it practical to go to much greater depths.

A turbine pump was recently constructed by the Pomona Pump Co. of Pomona, Calif., by which water is lifted from approximately 850 ft. underground. According to the manufacturers this pump is to be installed in Mexico for the Cia Industrial El Potosi at Zacatecas. The shipment required two railway freight cars and weighed 48,000 lb. without the electric motor.

The illustration shows the driving head and vertical motor to be used. A good idea of its size is gained from comparison with a man and one of the ordinary size driving heads. From the top of the motor to the lowest portion of the pump bowls measures 864 ft. The problem of proper lubrication and prevention of whipping in a drive shaft of such great length was successfully solved by using a water-lubricated resilient type bearing. The shaft floats within a film of water and all vibrations are completely cushioned.

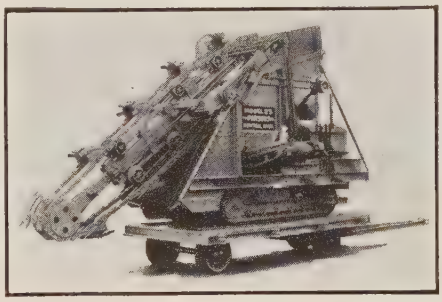
Twenty-five individual pump stages on bowls were used. Twelve of these were installed about 400 ft. underground and the remainder were at the 833-ft. level. Only one shaft is used, as the separate sets of stages drive from the same motor mounted at the surface. The capacity of each set is synchronized. An ingenious regulating device installed immediately below the top group compensated for increase in shaft length as the hydraulic load increased. The impellers have no lower shroud and are adjustable from the surface to compensate for eventual wear.

Driving Head and Vertical Motor of New Pump

The total weight of all moving parts is transmitted to an immense roller bearing in the pump head. This bearing runs in oil, the temperature of which is controlled by water-cooling coils.

New Parsons Ditcher

A new ditcher, the Model 25, for medium sized jobs built according to Parsons patented offset design on full crawler traction has been brought out by The Parsons Co., Newton, Ia. This machine fits right into the Parsons line of patented offset-boom full-crawler machines—coming naturally between the 21, which is designed for lighter trench work, and the 31, which handles the heavier water and sewer jobs.



The New Parsons Model 25 Ditcher

The 25 contains several advanced features which are claimed to be of particular advantage to a machine of this size:

1. Two bucket speeds which, synchronized with the four traction speeds, enable the operator to show large output and save power.

2. Two speeds on conveyor, to adapt it to yardage load at various ranges of digging.

3. Full-crawler mounting on an improved 3-point suspension.

4. Enclosed transmission with ground shafting, heat-treated gearing and roller bearings. This single transmission contains every operation, including traction speeds and reverse, conveyor drive and reverse, boom hoist and reverse, bucket drive and reverse —a compact working unit, fully protected in an oil tight case.

5. Conveyor frame of extra heavy construction, to meet severe digging conditions.

6. Boom hoist through shaft equipped with flexible couplings and connected to pull direct on the roller carrying the boom carriage.

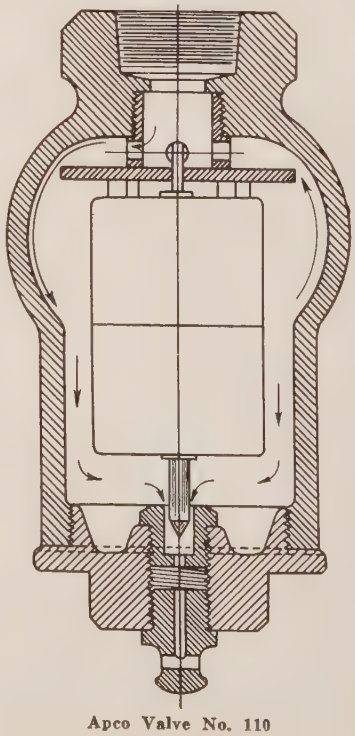
Because of its compactness, the Parsons 25 is easily handled, and easily moved from job to job. Where jumps are long the machine rolls quickly up onto a trailer.

The specifications of the Parsons 25 follow:

Digging widths, 15½ in. to 42 in.
Maximum digging depth, 10 ft.
Digging speeds (inch per minute), 11 in. to 139 in.
Digging speed changes, 16 forward, 4 reverse.
Bucket speeds, two.
Over-all dimensions:
Length when traveling, with longest boom, 27 ft. 6 in.
Length without boom, 16 ft. 2 in.
Maximum height, 11 ft. 8½ in.
Minimum height for shipping, 10 ft. 2½ in.
Width, 7 ft. ½ in.
Width over traction, 5 ft. 7½ in.
Weight, 23,000 lb.
Traction speed (miles per hour), 1.66.
Wheelbase, full parco.
Engine, 4 cyl., heavy duty type, 50 hp.
Conveyor:
Belt width, 20 in.
Maximum height to center line drum, 6 ft. 4¼ in.
Traction:
Tread width, 15 in.
Area, 2,790 sq. in.

Automatic Air Relief Valves

A complete line of automatic air relief valves designed for a wide variety of needs is now being manufactured by the Automatic Primer Co., 111 W. Washington St., Chicago, Ill. These valves are designed to release automatically accumulations of air from pipe lines, pumps and various types of tanks or vessels. They are stated to be simple and compact and to operate continuously without attention. The valves Nos. 50-60-70 are designed for pressures up to 125 lb. per square inch; valve No. 100 is designed for pressures not exceeding 200 lb.; and valves Nos. 110-120-130 for pressures from 250 lb. to 500 lb.



Apco Valve No. 110

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A New Profession, Research Engineering

The opening of a decade serves as a milestone where we should pause to review the economic progress of the preceding ten years. In America what has been the most outstanding economic development since January, 1920? There will be many differences of opinion. We suggest consideration of the rapid increase in the number of research laboratories as being the most important economic development, if not during the past 10, then during the past 20 years.

As we recall it, less than a decade ago "The Chemical Engineer" took the U. S. Steel Corporation to task for not having a research laboratory. Now it has one. This sort of advance has become a common thing among big American corporations. The next decade will probably witness the wide adoption of research methods by American corporations, small as well as large.

In the January issue of "The American Magazine," there is an interview with C. F. Kettering, president and general manager of General Motors Research Corporation. Note the title of that corporation, and bear in mind that it is a subsidiary of the world's largest manufacturer of motor vehicles. Mr. Kettering is a "famous research engineer," to use the designation that appears in that interview. Note also that designation. Ten years ago the title "research engineer" was almost unheard in America. Now there are probably several thousand who claim it.

"In his (Kettering's) laboratories at Detroit he uses his time and that of some 450 physicists, chemists, electrical engineers, mechanical engineers, mathematicians, and mechanics finding fault with General Motors products and thinking up ways to make them better and different."

About 14 years ago we gave the reason why the American Telephone and Telegraph Co. had been able to perfect transcontinental telephony. (See "Inventing an Inventor" in "Engineering and Contracting," Nov. 29, 1916.) That article ascribed the successful solution of that telephone problem to the then novel practice of cooperative research, in which a new combination of brains was devised to solve the problem. The article was widely quoted because of the novel idea that it described—cooperative research.

Cooperative research even 15 years ago was not entirely new in Germany, for several manufacturers of chemical products had well manned research laboratories. But shortly after the world war ended in 1918, when the du Ponts announced that they had organized a research laboratory that employed 3,000 technical men and assistants, there was open-eyed astonishment the world over. How could 3,000 researchers keep busy in any laboratory? That seemed incredible scarcely more than 10 years ago.

Many an engineer is dissatisfied with his economic prospects. To those that have a taste for research and invention, a comparatively new field is open. How to enter that field we do not intend to discuss now.

Many a young man is contemplating taking an engineering course, but is in doubt as to the college to attend and the course to take. We suggest giving preference to a course and a college that offer good training in research methods. Unfortunately few colleges specifically provide such training, for it has been erroneously thought that inventors and discoverers are "born and not made," whereas the fact is that they are born and made. More often than not they are wholly self-made, but this was equally true of civil engineers less than a century ago. The Military Academy at West Point was the first American college to teach any sort of engineering, and it was founded in 1802, "and for about 30 years was the only organized agency for engineering education in America." In 1865 there were fewer than 300 graduates of American engineering colleges exclusive of West Point; yet this country even then had made great engineering progress, largely under the direction of self-made engineers. So it has been with our research achievements up till very recently; but at last it is beginning to be realized that research engineering can be and should be taught as such.

When many young research engineers shall have been graduated, it will not surprise us if their achievements will revolutionize our present educational methods in every branch. After all, a college education accomplishes little that is worth while if it does not train a man to be a systematic, thorough investigator. So even now, the research spirit that is developed at college is the best part of any scientific training received there. However, that sort of training is usually a by-product, whereas it should be the main product, regardless of the degree of native originality of the student or his intended occupation in after life.

Every one of us has at least a modicum of originality. Every one of us is competent to search for and classify information, and the great majority of us can draw correct inferences if we have secured adequate data. Research training develops such native originality as we possess; but even if it failed to do that, it would still be excellent training, for it would habituate men to get the facts and all the gettable facts. Unfortunately, that sort of training is not yet very prominent in many of our schools and colleges.

The Inadequacy of High School Training

Commenting upon the Wall St. panic, an editor urges the teaching of the principles of finance in all high schools. Then, he reasons, there would not be such a large flock of lambs for the wolves to feed on. The suggestion is not without merit, for it has been obvious to those who know how to appraise values that the prices of many securities have long been far above those that their earnings justified. That economic principles should be taught in high schools seems a good suggestion. However, perhaps a better one is that school children should be trained to become habitual searchers for useful information. That they are not so trained is made evident by many facts.

Go into any of the scores of Carnegie libraries, or other public warehouses of wisdom, and inquire the average number of daily users of its books. Compare that number with the population served by the library, and you will quickly disabuse yourself of the illusion that we are an educated people. We are literate, yes; but literary, no. We read, but we study very little after leaving school; and that is simply because we were not trained there to be real students. Instead, we were given a series of rules that we were taught to apply to certain classes of problems, supplemented by a lot of facts that we were required to memorize. While only the slightest effort was made to teach us how to find principles and data useful in solving economic and other problems that confront us in endless sequence after graduation.

Yet a talk with high school teachers will soon convince you that they think they are training their students in the art and science of thinking, and they resent any intimation that their students are primarily memorizers and not thinkers. As for their students being searchers for information, they admit that they are not that, as a rule, but they argue that they will acquire that habit after graduation when the necessities of life force them to search. Well, the records of our libraries prove this last named belief to be an illusion. So, too, do the records of book publishers, for there is scarcely an informative book that should not attain a sale 10 to 20 times what it does reach.

Now we ask: Which is a preferable schooling, one that imparts a large number of economic and scientific principles and data to the students, or one that habituates him to hunt for them? It has long been conceded by educators that the mere teaching of isolated facts is a footless procedure, for facts are infinite in number and of widely varying utility. But it remains for educators to discover that it is almost equally footless to teach most of the principles that they teach. What is a scientific principle? If true it is merely a fact relating to a class of things; the principle of the lever is such a fact. The trouble is that the number of scientific principles and laws is already stupendous, and growing at an amazing rate, so that at best only a very small percentage of them can be learned at school or college. If it be argued that at least the most important principles can be taught there, the question at once arises as to how their relative importance is to be measured. Any careful consideration of this appraisal problem shows that the value of a scientific principle is entirely relative. To most men Newton's all-embracing law of gravitation is almost valueless. Even as engineers, how often do we need to know that the force of gravitation is directly as the product of the masses and inversely as the square of the distance between the centers of mass? Yet here is a principle that has been repeatedly called the broadest, exact generization in the whole realm of nature, for it applies to every particle in that realm and even to the so-called immaterial waves of light. To the astronomer, this law of Newton's is doubtless the most important of all laws. To the civil engineer it is almost valueless, and this statement applies to nearly all scientists other than astronomers. So it is evident that the value of a law or principle is not to be measured by the scope of its application but by the need of applying it in solving problems. Its generality, its admirable simplicity, its beauty may excite our admiration, but like the grandeur of an Alpine peak, it may lack utility and therefore economic value to all but a very few. To most of us, therefore, the law of gravitation is an Alpine peak. And when we carry this analysis farther we soon see that it is a perfectly fruitless endeavor to assign relative values to the different principles of science.

Turning to the other extreme of narrowness of a scientific principle, consider the principle that oil adheres to graphite more tenaciously than to silicates. Such a principle would scarcely be regarded as one to be taught at school, yet it became worth millions of dollars to those who applied it in separating graphite from its gangue.

Not only is the relative value of scientific principles dependent upon the problem in hand, but it often varies enormously within a few years, or even a few days. A principle that is of almost no economic value today may be almost priceless tomorrow if combined with some scientific discovery made tomorrow.

We are driven by such considerations as these to conclude that so far as mental schooling below the college grade is concerned, there should ordinarily be no attempt to teach scientific principles except to illustrate methods of acquiring and applying knowledge, and that the greater part of the student's time devoted to science (including economics) should be spent in searching for information in library and laboratory. Only by years spent in solving problems in which his own resourcefulness is called into play can the average student become sufficiently self-reliant to attempt to solve problems in after life. Lacking such training, the typical high school graduate is a pathetically helpless creature when he emerges into the business or professional world. This is not the worst of it, for the great majority never overcome that helplessness. Having spent eight or more years in routine study that calls for little or no resourcefulness, and having passed the time when habits are formed, the typical high school graduate never develops any resourcefulness, not even that mild kind of resourcefulness that leads him to study what others have discovered, with a view to utilizing their discoveries.

WATER & SEWERAGE WORKS

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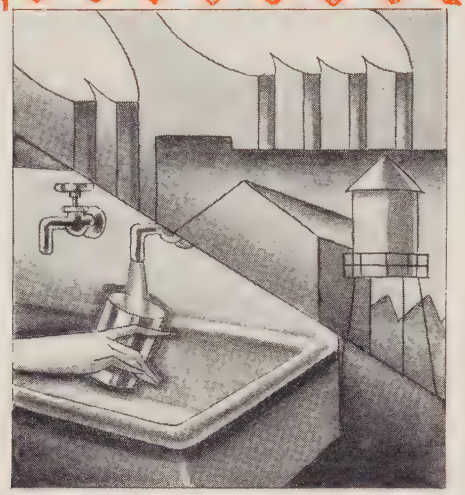
April, 1930 — H. P. Gillette Editor — Vol. LXXVII. No. 4

One of the Buildings at the Main Pumping Station of the Indianapolis Water Co., Containing 30 m.g.d. Vertical Triple Expansion Crank and Flywheel Pumping Unit and one 40 m.g.d. Centrifugal Pumping Unit.

MEMBER A. B. C.

HEALTHY CITIES are PROSPEROUS CITIES



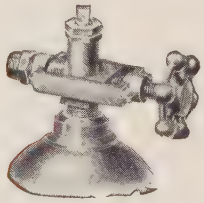
INCREASING HAZARDS

As city life grows more complex, attention is being given to the increasing hazards of disease. A counter movement is the establishment of plants for the treatment of sewage and industrial wastes.

Splendid progress is being made in this scientific endeavor, albeit much remains to be ascertained. It has been determined, however, that here, as in water sterilization, Liquid Chlorine may be employed with distinctly beneficial results.

Multi-Unit Tank Car

A valuable addition to the literature of sewage treatment is a booklet published by E B G. It is scientifically accurate, worthy of a place in your reference library.



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Water Works and Sewerage

H. P. GILLETTE, Editor

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Water Works and Sewerage

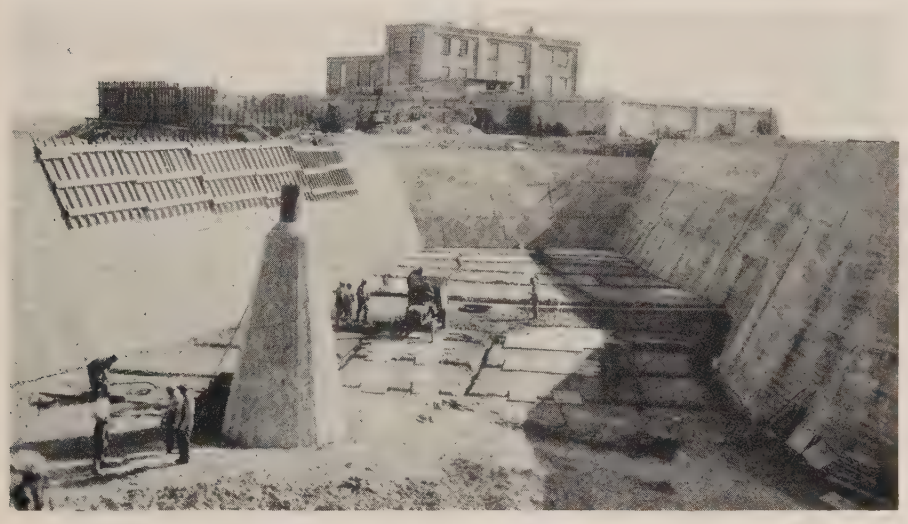
Vol. LXXVII APRIL, 1930 No. 4

Construction Methods on Cheyenne Reservoir

By P. R. REVIS

City Engineer, Cheyenne, Wyo.

Economical methods marked the construction of a storage reservoir at Cheyenne, Wyo., during the past year, as a part of a water-supply extension program inaugurated by the city in 1928.



Pouring Floor Slab, Cheyenne, Wyo., Reservoir. Trenches May Be Seen in Foreground

The filter plant has a capacity of 12,000,000 g. p. d. The water, after leaving the plant, is placed in storage reservoirs from which it enters one 30-in. and one 16-in. pipe line. The two lines carry the water to the distribution system in the city and also supply Fort F. E. Warren. These are also gravity lines, and Cheyenne has a constant pressure of 125 lb. per sq. in. in its distribution system.

When the original water system was constructed, one filtered-water storage reservoir, of 7,000,000 gal. capacity, was constructed at the site of the present filter plant. This reservoir was adequate until about two years ago, at which time plans were drawn for the construction of additional storage facilities.

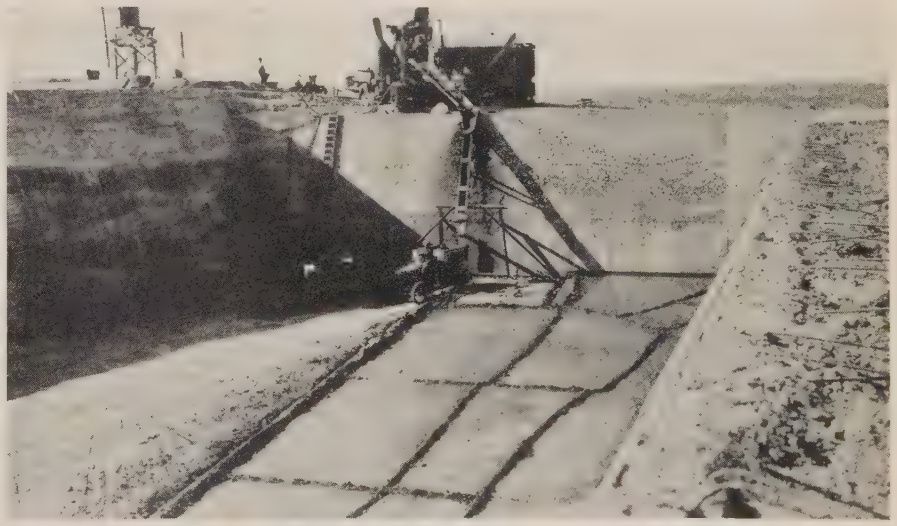
In order to maintain the same water pressure in the city and because of the peculiar contour of the hill upon which the filter plant and reservoirs are situated, several difficulties were encountered in the design. Too, it was proposed to have a capacity of 7,000,000 gal. in the new reservoir. The new reservoir may be described as having a peanut shape.

Earth excavated from the basin area was used as additional embankment along the outer wall. This earth, after compacting, was trimmed to a ½:1 slope to conform to the outside of the concrete wall. No outside forms were used. The walls were built in three lifts of 8 ft. each. Wooden inside forms were used and each section was 10 ft. in length, thereby simplifying the raising of the form sections for each lift. The concrete walls are 7 in. thick, with ½-in. reinforcing bars spaced 12 in. on centers both ways.

The first lift of the wall, being next to the floor, was designed with a key for the floor and reinforcing bars extended outward 3 ft. and embedded in the floor. Before concrete was poured on the floor, the base was divided into sections so that placing operations would not need to be discontinued at any time.

The floor was designed as a beam-and-slab type. The subgrade was first finished off, and trenches were then cut into the subgrade. The trenches when filled with concrete acted as beams. These beams were placed 14 ft. on centers. The slab and beams were reinforced with ½-in. reinforcing bars laid 12 in. on centers both ways. The walls were given a 1-in. coating of gunite.

The concrete for the walls and floor was mixed in a portable mixer which was operated along the walls as each section was poured. For the floor the concrete was chuted and buggies were used to move it to the section being poured. The concrete mix was 1:2:4. A careful check of the materials and a minimum use of water resulted in high-strength concrete as well as a saving in the amounts of material used.



Curing Reservoir Floor by Flooding

The actual cost, $52,435, included one 20-in. inlet, one 30-in. outlet, fencing and leveling of the embankment.

Weather Cycles Due to Planet Lowell

By HALBERT P. GILLETTE

IN the March issue of "Water Works and Sewerage," I called the ninth major planet Apollo. I had previously designated it as Planet "A." Announcement of the discovery of a planet having an orbital period of about 300 years was made by the Lowell Observatory on March 13, 1930, two days following my selection of the name Apollo for a planet that causes a magnetic cycle of about 317 years. In Prof. Lowell's original memoir, published in 1915, it was estimated that the ninth major planet has an orbital period of about 290 years. As the newly discovered planet is doubtless the one that Prof. Lowell originally predicted, and as its orbital period will probably be found to be sufficiently close to the 317-year magnetic cycle that is manifested by unusual auroras, sunspots and weather disturbances, it seems best to drop the name Apollo, and to substitute the name Lowell. Certainly if any astronomer was ever entitled to have his name given to a planet, it is Prof. Percival Lowell of Harvard. International jealousies deprived Herschel of the honor of having his name applied to what is now known as the planet Uranus. The almost simultaneous prediction of the longitude and latitude of Neptune, by Adams of England and by Leverrier of France, again aroused international jealousies that prevented either of those two astronomers from being honored by having the planet named after him. But no such condition, I trust, stands in the way of naming the ninth major planet after its real discoverer, the man who located its approximate position by its calculated effects on the path and velocity of Uranus. Although Prof. Lowell has been dead 14 years, the astronomers of the observatory that he founded were the ones to photograph and see this new planet for the first time, guided by his original calculations. The right to have the name Lowell applied to this planet has been doubly earned, first by Lowell the astronomer, and second by the Lowell Observatory.

Although I was right in my original inference that planet Lowell caused the great sunspot peak of 1778 (the greatest since sunspots have been accurately counted), I underestimated the length of the sunspot cycle due to that planet, calling it 290 years ("Engineering and Contracting," October, 1928). A few months ago I found that each of the eight major planets not only causes a sunspot cycle whose length is somewhat less than its orbital period, but that it causes subcycles whose lengths are one-twelfth of the length of the mian cycle. This discovery has enabled me to determine the length of each magnetic cycle with greater accuracy, for obviously a twelve-fold increase in the number of maxima adds to the accuracy of the estimated length between maxima. Planet Lowell itself furnishes as good an example as any of this use of subcycle maxima to establish the length of the main cycle.

I assume that each major planet has two "shells" of electrons, one in its upper atmosphere, corresponding to the "Heaviside layer" above the earth, and one in its liquid interior. Each of these two electron shells contains at least 12 permanent electron whirls. Photographs of Jupiter clearly show circular areas whose centers are about 30 deg. apart in longitude. The existence of 12 molten whirls in the earth is shown by topographical arcs (see "Engineering and Contracting." October, 1928, and October, 1929). Hence there is occular evidence of the existence of 12 major whirls on two of the planets, in their lower fields.

By assuming that the upper shell of electrons has magnetic poles that rotate slowly clockwise (when viewed from the north) about the axial poles, it is possible to explain how a planet can cause magnetic maxima on the sun at intervals less than the orbital period of the planet. I have derived a formula that shows the functional relationship between a planet's sunspot cycle and its orbital period ("Engineering and Contracting," October, 1928), and this formula fits the facts as to the eight planets so closely as to establish its substantial correctness. By this formula it can be shown that if the main sunspot cycle of Lowell has a mean length of 316.7 years, its orbital period is about 323 years.

In the case of the eight major planets the following formula shows an average error of only 2.5 per cent, and an extreme error of 10.7 per cent, hence it is presumable that its application to planet Lowell will give an error not exceeding 10.7 per cent, or about 35 years. If such an error occurs, Lowell's orbital period may be 358 years, but it can not be less than its sunspot period of 316.7 years, if my theory is correct. Hence Prof. Lowell's original estimate of 290 years is too low, and even the recently announced estimate of 300 years is too low. An excellent test of the correctness of my theory will be had if it shall ultimately be found that planet Lowell's orbital period is between 317 and 358 years. My formula for the relation of mean magnetic or sunspot cycles (t) to mean orbital velocity (T), when orbital velocity in miles per second is v, is

$$(1)\quad t = T(1 - .007\ v)$$

For the solar system this becomes:

$$(2)\quad t = T - 0.13^{3}\sqrt{T}$$

This formula gives the following theoretical lengths of magnetic or sunspot cycles, which are compared with the actual lengths.

Causative Planet	Cycle		Per Cent Difference
	Theoretical	Actual	
Mercury	69.7 days	70.3 days	+ 0.9
Venus	190.7 days	196.4 days	+ 3.0
Earth	10.44 mos.	10.93 mos.	+ 4.7
Mars	20.21 mos.	18.06 mos.	—10.7
Jupiter	11.19 yrs.	11.20 yrs.	+ 0.1
Saturn	28.24 yrs.	28.05 yrs.	— 0.7
Uranus	81.35 yrs.	81.11 yrs.	— 0.3
Neptune	161.97 yrs.	161.55 yrs.	— 0.3

It should be noted that in every case the magnetic cycle is less than the orbital period of the causative planet.

I find that the magnetic cycle of 316.7 years is so uniform that planet Lowell must have an orbital velocity that is quite uniform, which means that its orbital eccentricity is probably slight.

I think that Prof. Lowell's errors (if subsequent observation proves them to exist) as to the orbital period and the size of the ninth major planet, will be found to be due to the existence of planet "B," or Janus, whose magnetic and sunspot cycle is 633 years. If the longitude of this tenth planet has not differed greatly in recent years from that of planet Lowell, it would account for Prof. Lowell's difficulty in estimating more correctly the position, size and velocity of planet Lowell. In this event the visual discovery of the tenth major planet is likely to occur very soon.

Planet Lowell has a magnetic subcycle of one-twelfth its main cycle of 316.7 years, or 26.4 years, which is very pronounced in its weather effects. Its last maximum was in 1910 and its next will be in 1936.

In the next issue of "Water Works and Sewerage," proof will be given in detail of Lowell's 316.7-year magnetic cycle and its 26.4-year subcycle, based on sunspots, auroras, rainfall, tree growth, earthquakes, etc.

Lowering Ground-Water Level by Pumping

An interesting experiment is being tried on the Yuma reclamation project in Arizona to determine the feasibility of lowering the water-table by drilling wells and pumping the seepage water back into the Colorado River. The sum of $15,000 has been made available and a test well having a 24-in. casing will be driven.

The experiment will be watched with interest and should it prove successful other wells will be drilled in the valley. The proponents of the project hope that not only will the underground water level be lowered but also the wells may have considerable effect in leaching salts from the soil.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor
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Annual Meeting New Jersey Sewage Works Association

The general enthusiasm which attends all meetings of sewage works men was evident at the 15th annual meeting of this pioneer sewage works association in Trenton, N. J., March 21 and 22.

Over 250 men, hailing from Maine, Massachusetts, Connecticut, New York, Delaware, Maryland, Pennsylvania, Ohio, Illinois and Missouri made up the assemblage.

Glass Covers.—H. Burdett Cleveland, Consulting Engineer of New York City, described the features of the Red Bank, N. J., treatment plant recently completed. The plant has separate chlorination with provisions for drying the sludge under glass. Glass cover design with rather elaborate provision for ventilation was chosen as a precaution against odors at a site in close proximity to neighbors and highway, in preference to trying to seclude the plant at some distant site, the adoption of which would necessitate pumping with its attendant expense and uncertainty.

Edward F. Shissler, Superintendent of Works at Haddon-Heights, N. J., described a plant consisting of a two-story settling tank, a separate digestion tank, trickling filters, resedimentation tank and chlorinators. The feature of the plant is a glass cover enclosing both the drying beds and the sprinkling filters, which arrangement has made possible some very interesting investigations. Only a slight earthy odor changing to a soapy odor on the proverbial wash-day has been detected.

Control of Filter Fly.—Mr. Shissler showed that it is possible to control that sprinkling filter pest, the "filter fly," by closing the ventilators of the glass house and thus running the temperature up to from 129 to 147° F., these being the temperature attained on two separate treatment dates. Flies seemed to prefer the moist warm atmosphere normally within the covered area and seldom appeared outside. When the temperature was run up by closing the ventilators the flies were very largely killed off in 24 hours and completely so in 4 days. The latter period started the bed unloading.

It is curious to note that while Mr. Shissler felt some concern about this abnormal unloading of the filters, the next speaker, Mr. Chas. Hommon, Superintendent of Purification at Canton, O., emphasized the forced unloading of such filters as a very desirable feature in keeping the beds clean. Clean, to Mr. Hommon, means a degree of freedom from solid material which would have been considered suicidal a few years ago because it was thought that this accumulation was necessary to the action of the bed. Mr. Hommon forces the unloading and at the same time destroys the flies by the flooding method.

Mr. F. M. Veatch, Consulting Engineer of Kansas City, in describing operating experiences in the West, emphasized the necessity of training the city officials to appreciate the training of the operator and its purpose and profit to the city. He spoke of sewer rental laws as a step in the right direction.

Cost Data.—In commenting on operating and cost data on eight plants in the West he said that the tables of cost presented indicated clearly that additional money spent on raising operator salaries would be money well spent.

Costs presented varied from $68.50 per M. G. to a net profit of $3.62. The experiences tabulated in detail vary from those with an Imhoff plant at an elevation of 7,160 ft. and an average temperature of 40.8° F. to the irrigation farm at Tucson, Ariz., with torrid temperatures around 118° F.

At the Pomona, Calif., activated sludge plant he reports some difficulty with digestion of the activated sludge in the Imhoff tanks. This is lessened by returning the sludge to the tank influent rather than to the digestion compartment proper.

Mosquito Control.—The Jersey mosquito has put his sting into the sewage problem to further aggravate the misery of the operator. However, Mr. Lester Smith, Superintendent of the Middlesex County Mosquito Extermination Work, in a paper on breeding in catchbasins and cesspools, made it appear that while breeding about municipal plants is undesirable the breeding in improperly cared for cesspools is equally troublesome and much more widespread.

He indicated that a change in the design of catchbasins to eliminate the water well would stop the trouble from breeding in these basins. The cost of controlling breeding in 60,000 of these faultily designed basins in Northern New Jersey had been reduced to the sum of $20,700 only by the use of power oil pumps mounted on trucks so equipped that it is only necessary for the driver of the truck to hesitate while an accomplice pull the trigger on the oil gun.

Messrs. LeRoy Forman and Joseph M. Ginsberg, Ph. D. told of preliminary studies of the control of mosquito breeding in disposal plants. Investigations were made on five typical plants in the state to determine the toxic effect of various larvaecides on the mosquito and on the organisms responsible for purification processes.

Standard light oil's use as larvaecides had no bad effect on the organisms in filter beds. The addition of cresylic acid often used to keep such oils on the water surface was found to be detrimental when 10 per cent was added to the oils. Slightly detrimental in 5 per cent solution but harmless at 1.5 per cent. 1.5 per cent is just sufficient to accomplish the desired spreading of the oil.

In a round table discussion on mosquito control, Dr. T. J. Headlee, State Entomologist of New Jersey, told of particular instances of serious difficulties with mosquito breeding at municipal plants and emphasized the necessity of eliminating ponding and weed growth.

He said that a peculiar property of the food supply made available to mosquito larvae by improperly purified sewage is that it permits salt water mosquitoes to develop in fresh water and fresh water varieties to develop in salt water, greatly complicating the problems of the mosquito exterminators.

Sludge As Fertilizer.—Mr. Chester G. Wigley, Consulting Engineer, Atlantic City, described a method of using moulds to prepare green sludge for use as a fertilizer. This fertilizer is particularly adapted to conditions in At-

lantic City, where it sells for $20 per ton. Heat, darkness and limitation of air currents are essential to the growth of these moulds. An attempt is being made to supply heat minus light from the sun by using glass to bring in the light and transform it into heat and wooden baffles to keep the light from reaching the growing moulds.

Dr. Heukelekian, Biologist of the New Jersey Sewage Experiment Station, followed Mr. Wigley and expressed surprise at the success of the former since he himself had attempted something on the same order but found the green sludge too wet to properly support the growth of fungus and the expense of drying the sludge to a condition in which the fungus would flourish so great that ordinary digestive treatment had seemed preferable.

High Temperature Digestion.—Dr. Heukelekian then proceeded to describe his experiments with high temperature digestion. Ordinary digestion is facilitated by temperatures up to 82° F., after which it falls off to be superseded by thermophilic digestion at temperature from 115 to 150. The process gives promise of cutting the required digestive capacity to ½ cu. ft. and possibly ¼ cu. ft. per person.

Fortunately for the maintenance of these high temperatures digestion is not only quicker but more complete, the gasification of a greater proportion of the organic matter yielding a very much larger total quantity of gas.

Mr. Courtland H. Shute, Superintendent of Treatment at Glassboro, N. J., described the Glassboro plant and its operation. He gave special stress to plant beautification and selling the plant to the public in general and to the City Fathers in particular. He also mentioned the very important psychological effect of the condition of the plant on the men who work about it. Cost of operation of this plant for 4,000 persons is only 0.578 in spite of seasonal difficulties with cannery wastes.

Drying Sludge Under Glass Covers.—Mr. Floyd G. Brown and Mr. Frank W. Jones, of Marion, O., and Cleveland, O., respectively gave most interesting data on drying sludge under glass.

The number of glass covers in 1926 was less than 10, while at the end of 1929 there were more than 80. Most of these were built in 1928 and 1929.

They feel that drainage is the important thing during the first two days and that thereafter further drying is due to evaporation.

Affecting drainage are depth and condition of underdrains. Affecting evaporation are height of walls, type and location of walks, type and use of ventilators, etc.

The following data was given on drying at Marion, O.:

Suspended solids in raw sewage, mean, p.p.m.	227.
Volatile matter in green sludge, per cent.	75.1
Volatile matter in ripe sludge, per cent.	53.0
Loss of solids by digestion, per cent.	40.0
Average drying period (beds worked at cap.), days	16
Max. drying period required, days	43
Min. drying period required, days	6

Only 122 of the 314 days during which sludge was on the beds were clear or partly clear and 54.03 in. of rain fell so that without glass drying would have been very difficult.

With sludge 7 to 7.5 per cent solids and applied at depths of 8 to 10 in., 20 dryings per year are possible corresponding to 0.58 cu. yd. per square foot drying area.

The quantity of digested 7 to 7.5 per cent sludge equalled 6.1 cu. yd. or 1,200 gal. per million gallons of sewage.

Costs for glass covered drying beds complete are given as from $2.50 to $3.

Disposal of sludge is still the vital need.

Major Blew told of experiments at the Philadelphia plant with activated sludge treatment. He predicted the development of a semi-complete process with aeration from 40 min. to an hour.

A technical discussion of detention periods in sedimentation tanks by Mr. Elmer App and Mr. James R. Baty of the Bureau of Engineering, State Department of Health of New Jersey, was very interesting and projected a round table discussion among a party of engineers that lasted far into the night. A plea was made for support for further investigation of this very interesting subject.

Impressions of Meeting.—Summing up the impressions from the meeting:

Sludge disposal after drying is still the vital issue.

From three widely separated sources, three various means of preparing fertilizer from sludge and marketing it were brought out.

Uniform production of sludge is desirable from the marketing end and essential to the operating end. The two are therefore compatible.

Sewage disposal seems to be rapidly emerging from the state in which the plant was a thing to be buried and shunned to a state in which it is to be beautified and sold to the public.

Publicity is now the watchword and it is necessary to educate city officials up to the point where they will make use of the opportunities which the cooperative efforts of state health departments, operators and consulting engineers are making available.

Batch Boxes Given Sloping Floors

In reconstructing the Harahan viaduct, across the Mississippi River from Memphis, Tenn., and leading to the Harahan bridge across the river, the contractor used special batch boxes in industrial-railway trains. Each box had four compartments. The compartments were 1x4 ft. in horizontal section and 4 ft. high, and the bottoms were given a 40-deg. slope so that opening the side doors would empty the boxes quickly.

Carbonate Hardness Reduction at Columbus, O.

The following notes on the results of operating the new process for reduction of carbonate hardness by lime softening to the theoretical limit are taken from the annual report for 1929 of Charles P. Hoover, Chemist in Charge of the Water Softening and Purification Works of Columbus, O.:

During the years previous to the installation of the recarbonation plant, the average alkalinity of the filtered water was 51 parts per million. This past year (1929) the alkalinity of the filtered water averaged 30 parts per million. This further reduction in alkalinity has been made possible because of an improved process of operation that has been adopted. The adoption of this process has been made possible because of the recarbonation plant.

The process consists in:

(1) Applying from 25 to 50 parts per million or more of lime in excess of that theoretically required to combine with the free and half-bound carbon-dioxide and to precipiate the magnesium;

(2) Settling through first four basins;

(3) Carbonation in about the middle of the fifth and sixth basins to the point where two times the phenolphthalein alkalinity subtracted from the total alkalinity equals approximately 5;

(4) Settling in latter half of fifth and sixth basins and filtering through sand filters.

This process throws a considerable burden on the sand causing some incrustation and cementing together of the sand grains.

The following modification of the process has been developed and tried out in the laboratory with very satisfactory results.

(1) Use from 25 to 50 parts per million or more of lime in excess of that theoretically required to combine with the free and half-bound carbon-dioxide and to precipitate the magnesium;

(2) Settle out settable precipitates (this is preferable but not essential);

(3) Neutralize excess lime with carbon-dioxide gas;

(4) Mix with calcium carbonate or water softening sludge, approximately 1,500 more or less parts per million;

(5) Settle; and

(6) Filter.

The reduction of alkalinity or carbonate hardness to an average of 25 which, it is believed, can be easily obtained, instead of 51 as in past years results in a great saving. Had the process been known 21 years ago when the Columbus plant was put in operation, it would have saved in the chemical cost of softening Columbus' water supply over $400,000.

Sanitary Engineering in the Public Health Service

Duties of Sanitary Engineers in Administrative Positions in the U. S. Public Health Service, Particularly with Reference to Work in Eastern United States and the National Parks

By ARTHUR P. MILLER
Associate Sanitary Engineer, U. S. Public Health Service

IN this great country, the states have well defined duties and functions to perform and it is well understood that while the Federal Government may cooperate with and aid state and municipal boards of health in the execution of their rules and regulations, it must not transgress their rights. Obviously then, the relations of the Public Health Service officials with municipal and local health agencies, water and sewage treatment plant operators and the like are cooperative and advisory. Such contact as we have with them is always through and with the consent of the proper state officials and then is usually of an advisory character. The sanitary engineers in my service do not have opportunities comparable to those of state personnel to investigate, inspect and know individual water treatment plants in their own states. On the other hand, any one of our district engineers does have the chance in traveling over his large territory to know generally about water supply and purification matters in each state covered by him, even though he may not have intimate knowledge of all the details. With this general knowledge, we are in a position, in conferring with state engineers, to pass on to them whatever may be of value in their particular fields of activity. This opportunity to act in a liaison capacity has been very helpful not only to us but we believe to state personnel.

Besides the health affairs of the states, we must consider those of the larger unit—the nation. It can be recognized readily that where forty-nine political units are grouped together as closely as our states and the District of Columbia, some agency of broader scope than the state must be charged with the responsibility of caring for matters affecting health which either develop on the outside of our national boundaries or which involve more than one state. It is under such circumstances that the Public Health Service has a duty to perform.

Supervision of Water Supplies of Common Carriers.—Congress has recognized this and has charged the Public Health Service with the execution of certain specific duties only one of which I will touch upon. Although not exclusively, the Congressional Act of 1893 authorizes the Secretary of the Treasury to cooperate with and aid state and municipal boards of health in the execution and enforcement of rules and regulations made by the Secretary to prevent the introduction of contagious or infectious diseases into the United States and into one state from another. Under this Act the Secretary of the Treasury in 1912 issued the Interstate Quarantine Regulations. There is included in these regulations a section which states that "Water provided by any person, firm, company, or corporation for drinking or culinary purposes on any car, vessel, or other conveyance while engaged in interstate traffic shall be from a source which is approved by the Surgeon General of the United States Public Health Service as producing water of satisfactory sanitary quality and safety." You will now recognize one reason for sanitary engineers in the Public Health Service, namely, the supervision of water supplies used on common carriers.

To assure the quality of the drinking and culinary water on common carriers in 1912 was a large task, particularly with the personnel available at that time. The first step, which was taken in 1914, was to set up a bacteriological standard for the quality of that water. Using that as a working basis, state or municipal health authorities were empowered to certify to the Surgeon General the suitability of any source of water desired for use by any particular railroad. As we look back now on this system and bear in mind the stage to which water purification has advanced, we hesitate to consider just how successful this plan could have been in keeping water consumed by travelers satisfactory for that use. Another point which complicated the work then was that there were engineering divisions in but twelve state health departments. Actual records indicate that only fourteen states really functioned under this plan for certifying common carriers' water supplies.

Cooperation with State Health Departments.—In spite of deficiencies, however, the ground work was laid. In 1919 the present scheme was adopted, which involves close cooperation with all state health departments because of the fact that most of the field work necessary to ascertain the suitability of any water supply rests upon them. Using the reports made by the states, the Surgeon General of the Public Health Service issues annually proper certificates denoting approval or disapproval to common carriers on the supplies which they wish to use. This plan relieved the Service of the necessity of setting up a large field organization of its own, the activities of which would to a considerable extent have duplicated the work of the states and, on the other hand, it has been of much assistance in bringing about the establishment of engineering divisions in state health departments.

Another potent factor in this scheme has been the effect of the relatively high Treasury Department standards on the general character of the drinking water of the United States. This standard established by an advisory committee in 1922 is threefold and includes a sanitary survey and bacteriological and chemical limitations. Although it is not put out for general use, its application has become quite widespread. That fact, coupled with the necessity for many municipalities meeting this standard so that their water may be taken by common carriers has had an influence in raising the general plane of water quality throughout the country.

The relation of this work to the increase of engineering divisions has been mentioned. Some years ago the policy of the Service was to loan engineers to state health departments when they did not have their own engineering personnel. The duty of the loaned engineer was primarily to bring about the necessary investigations permitting the certification of common carrier water supplies and secondarily to assist the state in all other public health engineering work. This policy eventually brought many states to realize the helplessness of engineering personnel in their state health groups and resulted in quite a few states employing their own men.

From 1914 to 1922 engineering divisions rose in number from twelve to thirty-six and now there are forty-four. Today every state engages in this certification work although the Public Health Service personnel still helps in those states without engineers and even in some of the others. As recently as 1920 the percentage of completion of certification was only forty-two, but now it is something over eighty. Even though this percentage is still low, it is felt that a larger percentage of the traveling public receives satisfactory drinking water because most travel is to and from metropolitan areas and without exception their water supplies are in the approved group.

Decentralization of Certification Work.—At this time I wish to mention a plan now under consideration which

will materially decentralize the certification work and place more of it in the five engineering field offices of the Service. If it becomes effective it will bring the Public Health Service engineering staffs and those of the states into much closer contact.

We have considered now the sources of water but one must also think of it after it leaves the distribution system. This involves two very distinct problems—(1) the supplying of water to railroad trains, and (2) the furnishing of it to vessels, together with its purification and storage aboard.

Not enough has been done in the past on the first of these problems. How easy it has been under the schemes in use by railroads to destroy the purity of water by careless handling during the coach watering process! Consider the facts that previous to 1921 ice was placed directly in the water in coach coolers to chill it and that the methods often followed in ice handling and in safeguarding the sources of the ice itself were questionable. Reprint No. 1162 from the Public Health Reports gives a summary of the results of the efforts of the Public Health Service to have coolers on common carriers remodelled so as to exclude the ice from the drinking water. The following is quoted from that reprint: "This leaves but 1,330 coolers which, at the date of this writing (1927) have not been reported as having been rebuilt to conform with the provisions of Interstate Quarantine Regulations. This low figure represents 1.3 per cent of the total number of coolers reported as existing on cars operating in interstate traffic. It is believed that inquiry at the present time into the status of the few coolers reported during this survey as not being usable under the Interstate Quarantine Regulations will now show them to have been rebuilt."

Contamination by Careless Handling.—The effect on the drinking water of careless handling by railroad employees must be taken into account. During the past year my office has been studying by bacteriological methods the actual quality of the water in the train coolers and in so doing has had over 1,360 10 cubic centimeter tubes run through the complete bacteriological tests specified by the American Public Health Association. The percentage of those found to be positive, although not excessive cannot be ignored. The study will be completed during the coming summer. Paralleling this work we have undertaken surveys of practices followed in and facilities used for coach watering. Along a number of the major lines in the southeast, inspection of 73 watering points in 6 states have been completed.

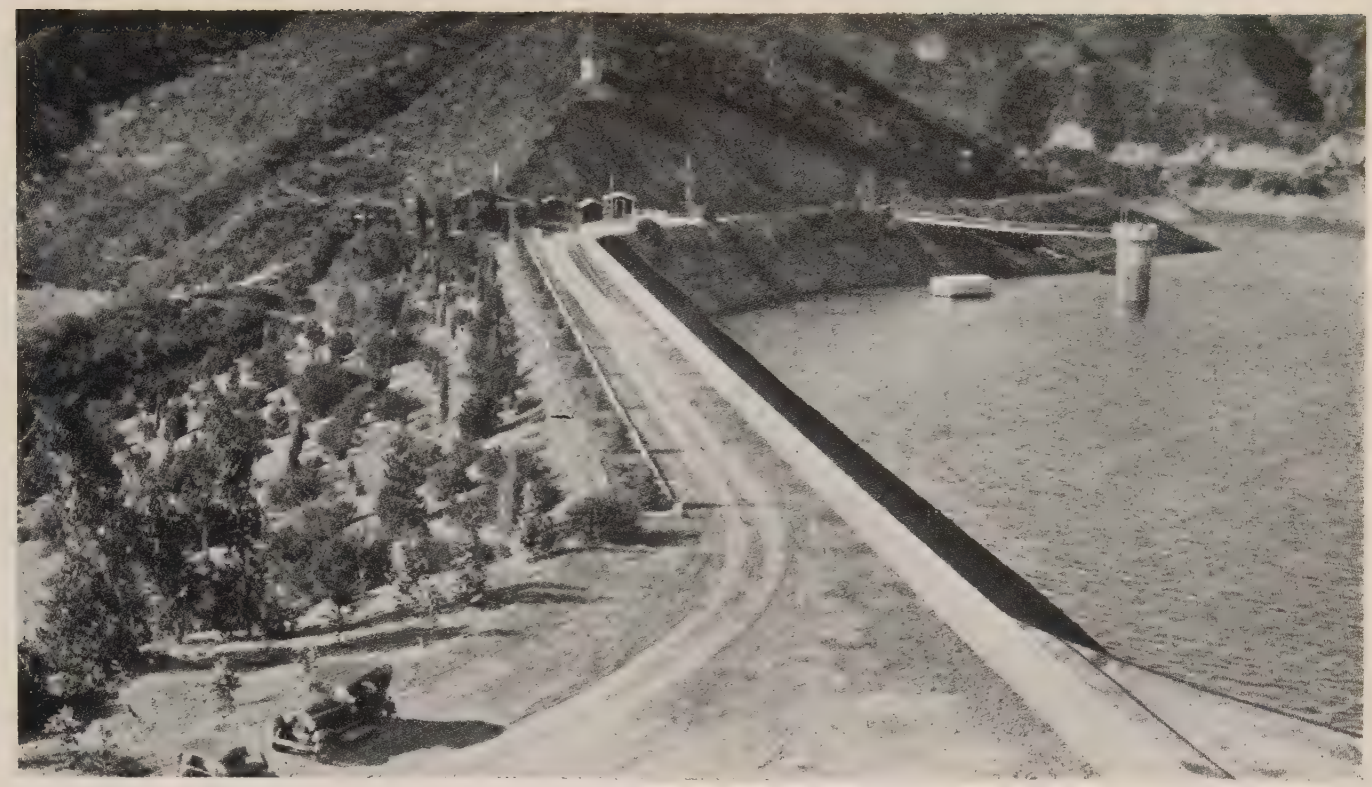
This problem is rapidly making itself felt in the railroad field. Some of the larger companies have taken hold of it on their own initiative and others have acted promptly when the matter was brought to their attention. The American Railway Association is now studying in a comprehensive way the whole subject of railway sanitation and much good should come from this study.

Water Supplies of Vessels.—Let us now consider the many vessels which traverse our coastal waters, lakes and rivers. Since the beginning of supervision of water supplies by the Public Health Service, the entire burden of assuring the continuation of the quality of a good drinking water after it has reached the vessel has been assumed by that Service. This involves a consideration of the methods used to transfer the water from the shore to the vessel and the examination of the complete water supply system on each vessel, including the storage facilities, pumping and distribution works and purification apparatus. One does not think often of the complexity of our large vessels but when it is remembered that many of them carry a number of passengers equivalent to the population of some villages, an idea of the work involved in checking a distribution system can be obtained. When this work was started it was all done by the engineers; now it is handled mostly by a group of engineering assistants, some of whom are employed only in the summer when ship operation is at its maximum. Vessel inspection is arduous but most of the engineers in the service not on research work have served an apprenticeship at it.

The problems of this phase of our activities differ but they may be roughly divided into the following classes: ocean going, river and Great Lakes vessels. The use of overboard water from the Great Lakes introduces an additional complication in that territory.

Like the water certification plan, a vessel certifying scheme was set up which to this day is functioning satisfactorily. As an indication of the

Landscaping on Down-Stream Slope of Sawtelle Pressure Break Reservoir, City of Los Angeles, Calif.



Landscaping on Down-Stream Slope of Dam of Stone Canyon Reservoir, City of Los Angeles, Calif.

magnitude of this work it might be said that in 1929 there were 2,243 vessels in what we call an active status. Seventy-two per cent of that number were acted upon that year. District 2 has only 6 per cent of the total number of vessels but 84 per cent of those were inspected and certified.

Tangible results have been obtained through this work, particularly in the Great Lakes area where overboard water was used with regularity in past years. Recorded official data show that in 1916 there were 70 cases of typhoid fever reported as occurring on vessels in that territory while in 1927 there were but two typhoid fever and three dysentery cases reported. Although the reporting of these diseases is not an exact measure of improvement, it does at least offer encouraging evidence. Both the water and the vessel certification procedures are now supervised and performed by engineering personnel.

Shell Fish Studies.—Drinking water is one of the most important bearers and transmitters of diseases but there are others. Milk has been responsible for quite a number of epidemics and lately shellfish has assumed considerable importance. An article appearing in the Public Health Reports in 1927 cites 26 instances of outbreaks of typhoid fever, gastro-enteritis and cholera in Europe and this country from 1815 to 1926 which could be traced to shellfish. Many of you will recall the outbreaks of typhoid fever in New York, Chicago and Washington in 1924 and 1925, in the study of which the Public Health Service closely involved the oyster. The oyster is a tasty food and should be eaten by more of us. Hence, to assist in maintaining it on the market as a food product, the Public Health Service upon the request of health officers and shellfish dealers undertook to assist in restoring public confidence in its safety as a food product.

The plan evolved to accomplish this, like that already in use in connection with water, is a cooperative one with state health departments. The Public Health Service undertakes by ample field work to measure the suitability and sufficiency of the machinery for and the methods used in doing the shellfish sanitation work in each state. We publish our opinions in the form of a list of certified dealers which is sent out to the entire United States. Where there appear to be deficiencies in a state's methods, personnel or equipment, an attempt is made to correct them. If this is not successful the Public Health Service can no longer assume the responsibility of advising all other states that the results in the deficient state are considered adequate but on the other hand must indicate the contrary by discontinuing activities in that state. In addition to that action, the dealers in that state are removed from the certified list. Through close cooperation with the other states and a number of large cities, the shellfish from a disapproved one are excluded by the others and without a ready market those shellfish cannot be sold easily. As you will see, this brings about remedial action in the dilatory state and the net results is a correction of the deficiencies found.

All of this work is now directed by engineers. Due to the location of District 2 more than half of it is done there and during the shellfish season it becomes a major activity. Field work involves sufficient inspections of shucking houses in each state to permit the formulation of an opinion as to the adequacy of the state's work, checking the activity of patrol forces covering condemned or restricted areas, and reviewing and assisting in the collection of data designed to effect the establishment or release of restricted areas.

To maintain the products of the shellfish industry in a suitable sanitary condition has necessitated much work on the part of the Public Health Service as well as the states. Our records show that during the season of 1928-29 there were 3,192 shucking house inspections made in the seven shellfish states in this area or an average of 443 inspections per month. This is equivalent to 0.6 of an inspection per shucking house per month. To check this work, there were 247 shucking house inspections made by District 2 engineers. These figures indicate that, although we are unable to see every shucking house each year, enough is done to permit the formulation of opinions as to adequacy and effectiveness of state control.

At first glance, one might consider an oyster shucking house not an ideal place for handling a food product often eaten raw. However, by bringing into these house a few simple and elementary sanitary rules and practices, by having them built so that the maintenance of cleanliness is easy and not

difficult, the chance of transmitting diseases has been reduced many times.

Where individuals have entered this industry with the idea of making a permanent business of it and not just a bare living and have re-invested some of their profit in their business as other progressive merchandisers do, the shucking houses are models. Some few plants are almost entirely mechanical with bucket conveyors and moving belts. In such a plant, the handling of the shucked oyster is reduced to a minimum and the facilities for cleansing both the oysters and the plant and its equipment are beyond criticism. Many states have had to provide more adequate facilities and additional personnel to undertake this program. For example, in Georgia where this work is under the direction of the Department of Agriculture, a sanitary engineer who I believe is probably the first one ever employed by a state agricultural department was hired to devote all of his time during the season to their sanitation program. The sanitation plane of this business in all its branches has risen rapidly in the last few years but perfection is still in the distance.

The control activities thus far discussed require more than half our time. They do not demand the skill of the designer or constructor but they do need a degree of mental adeptness as well as firm and tactful handling.

Work for Department of Justice.—This year, at the request of the Department of Justice, the Public Health Service has undertaken the sanitary engineering work for that Department. This involves five large institutions, two of which are located in the southeast. Thus far it has been necessary to supply these two penitentiaries with designs for such devices as a can-crushing and baling machine and an incinerator for combustible material. Plans for new sewerage and sewage pumps and milk pasturization equipment are under construction. A review of building plans, a revamping of the operation of a filtration plant, a study of a sewage treatment plant, and numerous other miscellaneous matters have had to be handled. This type of work presents a variety of problems comparable to those met in state work.

In accord with Service policy similar cooperative work is carried on with the Indian Bureau. All needed sanitation in 104 agencies in the United States is done through the Public Health Service district engineers' offices. One of the problems of my office in that connection has been the design of a new water suply system for the Cherokee Indian Agency in North Carolina.

Sanitary Engineering for National Parks.—In 1921 a plan was arranged between the National Park Service and the Public Health Service for engineering personnel of the latter to do the sanitary engineering work in the national parks. I was assigned to the San Francisco office from where this work was directed, as an assistant engineer. For three years, the summer periods were spent in Yellowstone, Glacier and Rocky Mountain National parks. The problems in all of the national parks at that time were almost overwhelming. Annual increases in travel through them were astonishing and unfortunately the facilities for handling these sudden increases were not adequate. It was almost impossible to build up to the needs.

The scope of work planned for the first summer in Yellowstone is brought out in the Service's Annual Report for 1921. There were included the preparation of designs and estimates for sewerage systems and disposal plants, the measurement of sewage flow at several points to obtain data for additional designs, the ascertainment of the quality of the many small drinking water supplies in the park and the closing up of those found not suitable, the preparation of estimates and plans for mosquito eradication at several points, the location of sorely needed water supplies, and general inspection work. By 1923, two complete sewerage system and treatment plants had been installed and plans had been prepared for similar works at two other points. The other matters mentioned above had been started and in many cases were well on their way to completion. In addition, time and thought had been given to the preparation of a suitable scheme for the collection and disposal of both combustible and non-combustible wastes. This problem eventually was solved by the adoption and installation of incinerators and can-crushing and baling machines.

This work has gone forward. Some of you are probably familiar with the new sewage treatment plant (9) at Grand Canyon National Park which produces an effluent that meets the Treasury Department standards for drinking water. Last June, 120,000 gallons of sewage per day were reclaimed at a cost of less than $100. This amount of fresh water was valued at $300. The net daily saving therefore, is more than $200. Other matters now in the forefront in this national park work include designs of comfort stations and sewage disposal plants for Glacier, a new sewage treatment plant at Yosemite, preparation of plans for remodeling a swimming pool in Yellowstone, and for a suspended sewer line over the Merced River in Yosemite, and recommendations for remodeling an incinerator in Sequoia.

Like all engineering of offices, ours receives the full share of requests requiring special attention and investigation and the usual reports and miscellaneous details take of our time, but the main duties of the engineering personnel attached to district offices are briefly covered herein.

Acknowledgment.—The foregoing is an abstract of a paper presented March 21 at the West Virginia 5th Annual Conference on Water Purification.

Water Softening at Columbus, O.

With the close of the year 1929 the city of Columbus, O., completed 21 years of water softening. The following general resume of this experience is taken from the annual report for 1929 of C. B. Hoover, Superintendent:

Resume of 21 Years of Water Softening

Gallons delivered to city	162,496,000,000
Average gallons per day during period	21,200,000
Total hardness removed in ppm	26,656,000
Average hardness removed in ppm.	164
Average hardness removed in grains per gal	9.75
Total tons of lime used	110,972
Pounds of lime per part of hardness removed per M. G	8.3
Total cost of lime	$843,356.98
Pounds of lime used per M. G	1,360
Average price of lime per ton	7.60
Total tons of soda ash used	53,836
Pounds of soda ash per part of hardness removed per M. G	4.0
Pounds of soda ash used per M. G.	660
Total cost of soda ash	$1,639,122.68
Average price of soda ash per ton	30.45
Total tons of alum used	22,975
Total cost of alum	$311,573.01
Average price of alum per ton	13.56
Total tons of chlorine used	115
Total cost of chlorine	$16,666.94
Average price of chlorine per ton	144.93
Total tons of coke used (since August, 1927)	1,290
Total cost of coke	$7,257.30
Average price of coke per ton	5.61
Total cost of all chemicals	2,817,976.91
Average cost per year during 21 year period	134,160.00

Unit Chemical Cost for the 21 Year Period

	Cost per M. G.	Cost per Part Hardness Removed
For lime	$ 5.18	$0.0316
For soda ash	10.09	.0615
For alum	1.91	.0117
For chlorine	.10	.0006
For coke	.24	.0018
For all chemicals	17.52	.1072

Ohio Water Conference

The 10th annual Ohio Water Purification Conference will be held in Columbus, O., Oct. 14-15. As this year's Sewage Treatment Conference will be held in Dayton Thursday and Friday of the same week, proximity of the conference cities and dates will make it convenient for those who wish to attend both sessions to do so without excess of travel or undue loss of time.

The Water Purification Conference is made up of men directly in charge of water purification plants, who meet annually to discuss the most recent developments in water treatment practice. Officers for the current year are:

O. F. Schoepfle, Superintendent water purification plant, Sandusky, chairman; F. E. Sheehan, Superintendent water works, Portsmouth, vice-chairman J. M. Montgomery, Superintendent water works, Piqua, secretary-treasurer; J. Sheldon Scott, Superintendent water purification plant, Steubenville, executive committeeman-at-large; T. R. Lathrop, Assistant Engineer Ohio Department of Health, editor annual report.

Labor-Saving Equipment on Water Project

Construction Methods and Equipment Used in Handling Earth, Concrete and Forms for the New Howard Bend Filtration Plant of St. Louis, Mo.

A project notable for the number of labor-saving methods and pieces of equipment developed for the handling of earth, concrete and forms was the construction of the new water plant for the city of St. Louis, Mo., situated at Howard Bend on the Missouri River, approximately 13½ miles west of the city limits.

This plant combines an intake from the river with a filtration plant for clarification of the river water. It will have an ultimate capacity of 200,000,000 g.p.d., and its total cost is said to be in the neighborhood of $12,000,000.

In Fig. 2 is shown a ramp-and-conveyor arrangement used for placing the concrete footings of the walls of the 100-m.g. clear-water reservoir. A ramp leads to a portable hopper, mounted on steel wheels and running on a plank track. Trucks backed up the ramp and discharged concrete into the hopper, from which the mix was withdrawn through a gate operated by hand on to a belt conveyor. This conveyor, about 20 ft. long, was inclined at an angle of about 25 deg. with the horizontal. Concrete was discharged from the conveyor belt into chutes, through which it was distributed to the footing forms. The conveyor, built by the General Conveyor Co., was driven by a gasoline engine and was moved along the forms by hand. When it was found necessary to move the hopper, the ramp was raised slightly and the whole outfit was drawn forward by a tractor. Portability was the essence of this arrangement, and it is believed that this scheme was more satisfactory than an attempt to cover the whole area from a single central point would have been.

Figure 3 illustrates setting of the Blaw-Knox wall forms for the settling-basin walls, and also the skip hoist used in pouring the walls. The forms were placed with the aid of the steel gantry, which operated on rails laid on each side of the footing. The inclined hoist was powered by a small gasoline engine.

Figure 4 shows the movable tower used for concreting the walls of the 100-m.g. clear-water reservoir. The ramp was mounted on double-flanged steel wheels, running on 60-lb. rails laid on cross-ties. The bottom 5-ft. section of the Insley mast was hinged, so that it could be raised from the ground when a move was to be made. After each move, this section was lowered, giving a secure foundation on the ground. The tower was provided with a ¾-yd. bucket, operated by a steam hoist. In moving, after the ramp and the bottom section of the tower had been raised, the outfit was propelled by means of a cable running from the hoist to a deadman between

Fig. 1—Tower Used in the Construction of the Howard Bend Filter and Headhouse

Fig. 2—Ramp and Conveyor Arrangement Used for Placing Concrete Footings for Walls of Reservoir

the rails. This photograph also shows the gantry used in placing the forms, and delivery of concrete by means of trucks.

In Fig. 5 is shown the portable ramp and belt conveyor used in placing earth fill back of the walls of the 100-m.g. clear-water reservoir. The conveyor was 36 in. in width and 100 ft. long. Earth was carried in dump wagons drawn by mule teams. The teams ascended the ramp and the wagons were dumped into a hopper. The hopper was provided with a trap-door to allow the passage of the mules. The ramp was mounted on skids and the conveyor on steel wheels running on plank tracks. The outfit was moved along the wall by a tractor. In operation, the hopper discharged on to the belt, which deposited the earth on the far side of the wall. The conveyor was driven by a 50-hp. gasoline engine.

Figure 6 shows a home-made skip hoist used for placing concrete in the boiler house. A small mixer is seen in the foreground. Aggregates were handled in wheelbarrows. In Fig. 7 is shown the tower used for placing concrete in the coagulant house.

Concrete for the Howard Bend plant was mixed at a central plant over a mile away from the site. Aggregates were brought in by rail and stockpiled, pending storage in bins by a locomotive crane. Cement was delivered in bulk and transferred to bins at the plant by a bucket elevator. Concrete was mixed in a 1½-yd. Smith tilting mixer, driven electrically. Proportioning was by volumetric measurement of sand and gravel and weighing of the cement. The strength of the concrete was controlled by the water-cement ratio. From the mixer, the concrete was elevated by means of an Insley

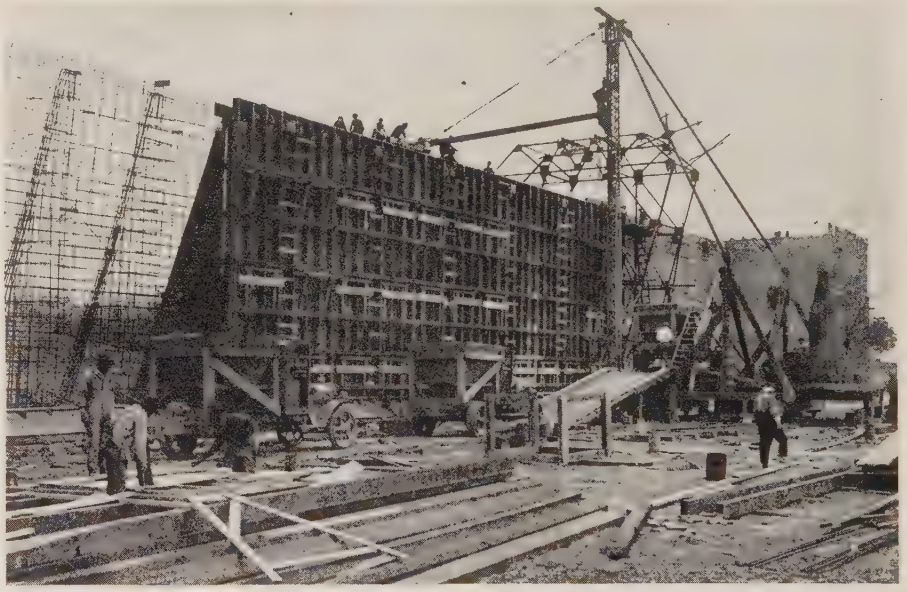


Fig. 4—Movable Tower Used for Concreting the Walls of the 100,000,000 Gal. Clear Water Reservoir

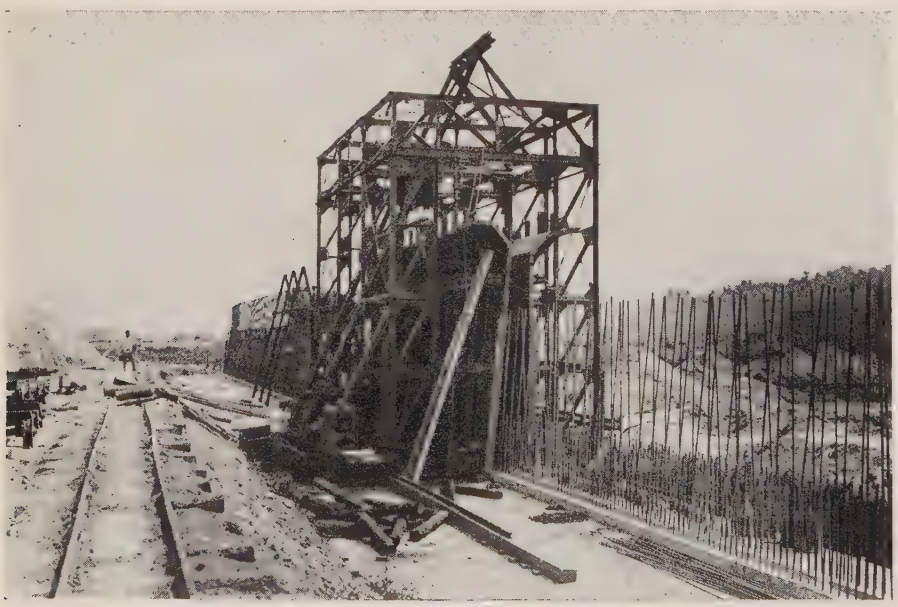


Fig. 3—Setting of the Wall Forms for the Settling Basin Walls; View also Shows the Ship Hoist Used in Pouring the Walls

tower and chuted to a hopper, from which trucks were loaded.

Considerable interest attaches to the construction of the covered basins, the concrete decks of which were supported by precast concrete columns poured at the site. About 1,700 of these columns, which were 14x14 in. in section and about 35 ft. long, were required. The columns were cast in quantities in horizontal forms. Column footings were cast with square holes to take the column bases. The columns were set with a tractor-mounted crane. The deck slabs were doweled to the column heads.

Construction of the intake necessitated the building of a cofferdam 110x 140 ft. in area. Steel piling was used in the construction of this cofferdam. A number of concrete piles were driven to form a foundation for the intake building.

Before construction of the plant was begun, considerable control work in connection with the river banks was

required in order to prevent encroachment of the stream upon the plant site. A revetment about a mile long was built about a mile above the plant, at a point where it was necessary to guard against scouring during high water. The bank was given a uniform slope by means of a hydraulic gun, and mats were sunk and held in place by rocks.

Between the lower end of the revetment and a point below the plant intake, a number of retards were built out at right angles from the shore. The retards are placed in groups of three, chained together. Trash of various sorts collects behind the retards and the resultant slowing-up of the current causes a deposit of sedi-

Fig. 5—Portable Ramp and Belt Conveyor Used in Placing Earth Fill Back of Walls of 100,000,000 Gal. Clear-Water Reservoirs

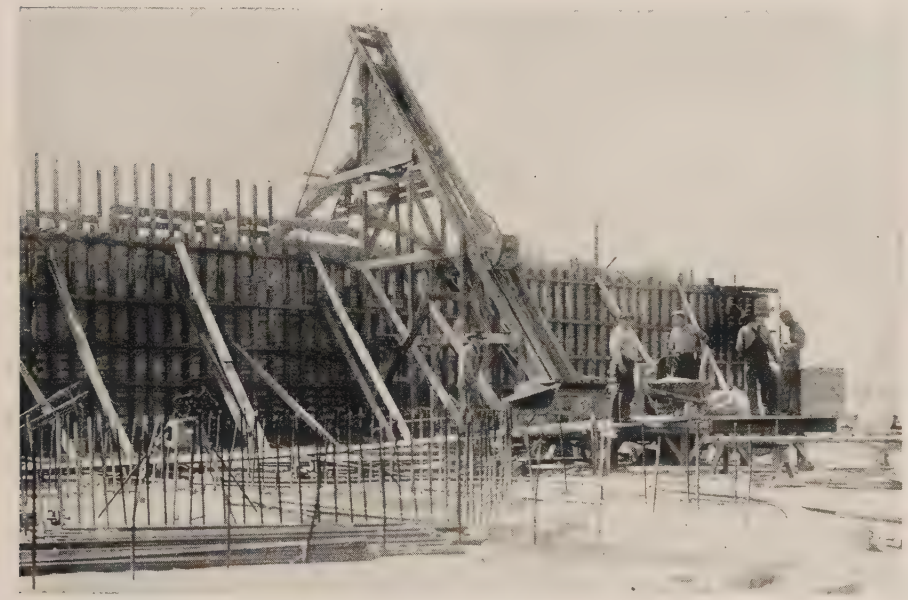


Fig. 6—Home-Made Skip Hoist Used for Placing Concrete in Construction of the Boiler House at Howard Bend Plant

ment. Thus the bank is afforded a continual protection.

The Howard Bend plant was designed by the engineers of the Water division of the Department of Public Utilities, under the direction of L. A. Day, water commissioner. Construction of the plant was divided among a number of firms of contractors.

Color and Organic Matter Removal

During the fiscal year ended June 30, 1929, an important piece of research work conducted in the laboratory of the Reservoir and Pumping Plants Division of the Department of Water and Power of Los Angeles, Calif., was a study of the Harbor District water in an effort to devise a treatment process to remove color and organic matter. The following note on this work is taken from the 28th annual report of the Board of Water and Power Commissioners.

Owing to the characteristics of this water, the problem was a complicated one necessitating much investigation. Conventional method of water treatment failed almost completely and combinations of several chemicals which would do the required work were too expensive and too cumbersome to be practicable. It was finally found that ferric chloride used by itself and in comparatively small doses was sufficient to remove all of the color, rendering this water physically perfect. A small experimental sand filter was erected in the laboratory and operated for some time with such uniformly satisfactory results that it was decided to build an experimental treatment plant at Wilmington for the purpose of refining the details of treatment. Designs for this plant have been completed and its construction ordered. It will handle, at conventional rates, 72,000 gal. of water per day and it is believed, will give valuable knowledge and experience in the treatment of this unusual water.

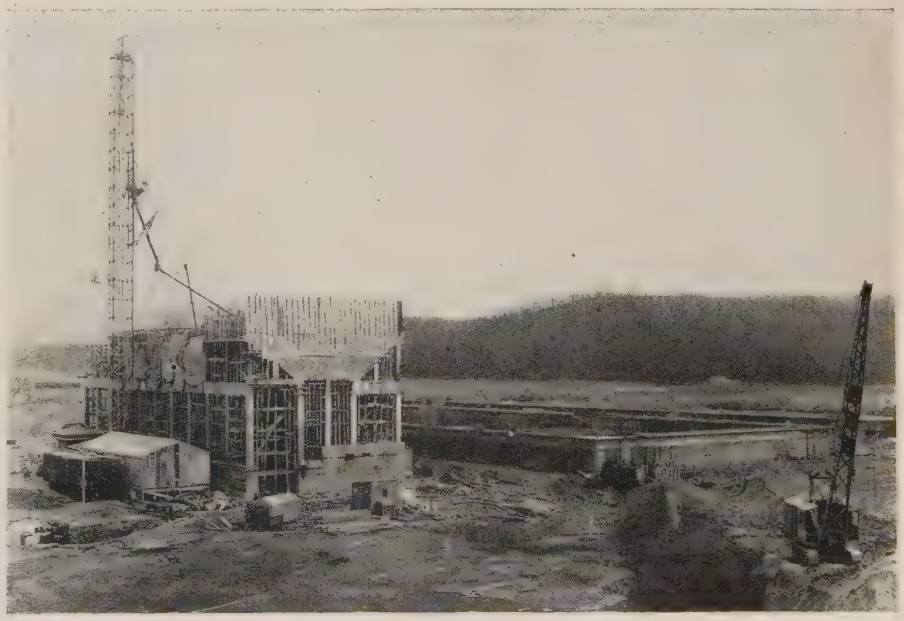


Fig. 7—Tower Used in Placing Concrete for the Coagulant House for the New Howard Bend Water Works Plant of St. Louis, Mo.

The Well Driller and the Water Works Field

Advances That Are Being Made in the Methods of Drilling and Finishing Wells for Public Supplies

By A. G. FIEDLER

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IN considering the facts that about half of the people of the United States use water supplied by wells and that about three-fourths of the cities and villages that have waterworks draw upon underground supplies, it becomes apparent that the water-well driller is engaged in a business that is intimately associated with the health and well-being of the public. It is estimated that there are about 8,000 cities and villages in the United States that have public waterworks and about 6,000 of these are supplied by wells. The largest well system in the country is the one which formerly supplied most of the water for Brooklyn, before that city became a part of the greater New York; it has a capacity of about 100,000,000 gal. a day. Many of the smaller systems, which supply innumerable villages scattered throughout the country, have a daily capacity of only 100,000 gal. or even less. Altogether about 17,000,000 people are supplied by public waterworks that derive their supply from wells.

Twenty Thousand Drillers in U. S.—I have estimated that there are about 20,000 drillers in the United States, of whom probably more than 10,000 are actively engaged in the business. During an average year many thousands of wells are drilled, representing an expenditure of many millions of dollars. Although the number of wells drilled especially for municipal water supplies represent probably less than 5 per cent of the total number drilled each year, yet these wells involve a much greater percentage of the annual expenditure because they are generally of more than average size and depth. Unfortunately no complete survey of the well-drilling business has ever been made, and it is difficult to make a reliable estimate of the extent of so widespread a business without more basic data.

The men engaged in well drilling have much in common with the members of the waterworks profession. By reason of the fact that the ultimate goal of both is the same—namely, that of furnishing an abundant and convenient supply of pure water to the people—the well driller can appreciate some of the difficulties of the waterworks man in getting the water delivered to the ultimate consumer. Contrary to the conception which prevails in some quarters, the business of drilling wells is not without its difficulties and hazards. In fact, it can be safely said that this business has more than its just share of hazards of failure, because the driller must conduct his work from the surface while his tools are working away unseen several hundred or thousand feet beneath the surface. Under such conditions many circumstances can arise that can ruin the patient work of many days and threaten the completion of the job. Because of these extra hazards, which are an integral part of the business, the experience of the man behind the drilling machine, is especially important.

Well Drilling Has Many Hazards.—As an illustration of some of the difficulties encountered in deep-well construction I may mention that recently one of the deepest cable-tool fishing jobs on record was being done in a well at a depth of 9,379 ft. Though this particular job arose during the construction of an oil well and was done at a much greater depth than that usually involved in water-well construction, it is a rather impressive illustration of the fact that the drilling of wells is a highly technical business, requiring men of skill and mechanical training.

Even in an area that has been thoroughly explored by other wells, which have disclosed the character, thickness, and water-bearing properties of the different formations, the problem of obtaining additional supplies of ground water is not necessarily a simple one, although such information in regard to any locality is indeed of great value. In the final analysis the driller' task is to construct the well in such a manner that it will not only make a sufficient quantity of water of suitable quality available but also yield the greatest quantity of water at the least expense.

The Important Feature of Drawdown.—This fact suggests a most important point, which is generally overlooked by engineers and water-supply men in the specifications for the construction of a well. Usually the specifications are centered around the quantity of water to be obtained from the well, and no mention is made of the equally important feature of drawdown. In view of the fact that, within certain limits, the yield of a well increases according to the drawdown, it becomes evident that the rate of yield alone gives insufficient information for judging the capacity of a well and that the amount of drawdown or the specific capacity of the well should also be given. For instance, if a well yields 250 gal. a minute under a drawdown of 10 ft., its specific capacity or rate of yield per unit of drawdown is 25 gal. a minute per foot of drawdown. By doubling the drawdown the yield is also practically doubled, and so on. It is evident, therefore, that the yield from any well could be increased by installing a pump of greater capacity, but because the drawdown would become greater under such increased yield the cost of pumping at the increased capacity might be prohibitive.

The specific capacity of a well that ends in creviced or fissured rock can not be controlled to any great extent by the driller, because it is governed largely by the number and size of the crevices that are encountered by the drill, but the specific capacity of a well ending in gravel and sand can generally be greatly increased through proper methods of development. This problem is gradually receiving increased attention by engineers and water-supply men, for it has a vital bearing on the economical operation of the water-supply system. The qualified well driller also realizes the importance of drawdown and will gladly assume the responsibility of obtaining the greatest possible specific capacity if he is properly recompensed for constructing a well of high efficiency.

Determining Feasibility of Ground Water Supply.—In the smaller municipalities, where detailed geologic examinations have not been made, the problem of determining the feasibility of using a ground-water supply or of obtaining an additional supply is frequently placed largely with the well driller. In territory in which the ground water is contained in the joints and crevices of hard rock wells of small yield are not uncommon. Where the ground water occurs in the interstices of unconsolidated material the driller is confronted with the problem of separating the water from the sand—a task which may be very difficult but which if properly done may result in wells of large capacity. Other difficulties may arise in attempting to drill a straight hole through beds that are tilted at a high angle or to carry the hole through beds of quicksand that readily heave into the pipe. All these problems are constantly being encountered in the construction of wells, and their solution requires the exercise of great ingenuity and patience.

The elements of skill and experience, together with adequate equipment, play a vital part in the successful completion of work of this character. Although the usual run of drilling difficulties are to be expected in any job, at times unforeseen troubles may occur

and seriously interfere with the early completion of a well project. These difficulties fall chiefly in the class of "fishing jobs." They involve the recovery of tools that have been lost in the hole, the removal of defective pipe or casing, and the recovery of tools that have wedged fast and can not be readily withdrawn. Many of these difficulties can be avoided by the use of good equipment and the exercise of skill in handling tools, but even the most skilled operators are not immune from them.

It can therefore be readily seen that the well driller is confronted by many problems and difficulties which can not be fully anticipated when the specifications for a well job are drawn up. Obviously it is unfair to require the driller to guarantee a given quantity of water under specifications that state in detail the methods and manner in which a well shall be constructed, without permitting him to exercise his own judgment on problems of construction.

How the Driller Can Assist the Water Works Man.—There are three particular fields in conjunction with ground-water supplies in which the driller can be of real assistance to the waterworks man. One of these fields has to do with the quantity of the water, another with the quality, and the third with the method of constructing and finishing the well.

Most growing communities are confronted by a recurring problem of a shortage of water supply. Favorable location in reference to transportation, topographic features, and a prosperous surrounding country may provide conditions that would promote a marked increase in the growth and wealth of the community, but without an adequate water supply of suitable quality to take care of such expansion the prospects for continued development are greatly curtailed. Because the larger cities require such enormous quantities of water to satisfy their needs, they are continually having to go farther afield to obtain adequate supplies—many of them now going 50 or 100 miles or even more than 200 miles. The expense of such an undertaking is far beyond the capacity of the small municipalities, and of necessity they are limited to supplies that are closer at hand. An adequate source of surface water may not be readily available, or the expense of treating the surface water in order to make it fit for domestic use may be great, so that attention is given to the possibility of developing an adequate ground-water supply. Under such circumstances the driller can make a real contribution to the welfare of the community, for by means of test drilling or literally prospecting for water, just as the valuable minerals of the earth are prospected for, he may be able to locate ground-water supplies that have previously been passed by unnoticed or considered inadequate.

The demand for water of low mineral content is a problem that confronts many of our municipalities today. Large quantities of water that will be satisfactory for boiler use are required, and the selection of sites for plants engaged in special manufacturing processes is largely based upon the availability of a water supply of high quality. Increasing attention is also being given to the hardness of water used for domestic supply, because soft water in the home results in material savings in the consumption of soap and is otherwise much more satisfactory for domestic use.

The Wells at Canton, S. D.—The value of the services of the well driller in obtaining a water supply of higher quality are well illustrated by the results of work done in the vicinity of Canton, S. D., where soft water was discovered by the drillers in the Dakota sandstone and where formerly the supply had been obtained from terrace gravel that yield very hard water.

The third named field in which the driller can be of particular assistance to the waterworks man is more or less closely related to the problems of quantity and quality. It involves not only the hardness but also the sanitary quality of the water, for the method of constructing and finishing that is used has a vital bearing upon the problem of preserving the original purity of the supply.

Preventing Well Contamination.—I have been informed that considerable trouble has been experienced in this state with contaminated water from shallow depths running down the outside of the casing into the well. The usual methods of preventing such contaminated water from entering the well at the top of the casing, by tight sealing and a concrete platform or covering are relatively simple in application, but where they are not effective the problem is largely one of sealing the casing beneath the surface so that contaminated water can not percolate from one formation to another and hence enter the well. Cement is an excellent material for this purpose, and fortunately satisfactory methods have been developed for adapting it to the needs of water-well construction. Practically all the methods of cementing wells have been developed in the drilling of oil wells, where difficult water problems are frequent, though none of them are more important than the problem encountered in water wells of protecting the purity of water used for domestic supply.

In water-well construction where cementing materials are not used, objectionable water in overlying beds are normally excluded by seating the casing in a relatively hard and impervious stratum, thereby shutting them off. Where this is impossible, packers are frequently used, but in view of the fact that the packing material is normally subject to deterioration this method is not recommended for the best type of construction. In wells drilled by the rotary method, heavy, mud-laden fluid is circulated behind the casing and serves a beneficial purpose in preventing percolation of water behind the casing and in delaying deterioration resulting from the action of corrosive waters. In many localities it is impossible to find a hard and impervious formation upon which to set the casing and is thus difficult to prevent the percolation of water along the casing and into the well. Under such conditions cement properly applied will prevent the entrance of the contaminating waters.

Methods of Cementing Wells.—Three methods of cementing wells are in use—the dump-bailer method, either with or without the use of "cement plugs"; the tubing method, without plug or with one plug; and the casing method, with plug above and below cement or without plugs.

The dump-bailer method of cementing is probably the simplest and requires the least amount of special equipment. In this method cement is placed in the bottom of a well with a dump-bailer after the casing has been raised from its seat. The casing is then lowered after it has been filled with water and sealed or the lower end has been closed with a suitable plug. As the casing is lowered the cement is forced up on the outside of the pipe and is permitted to set.

In the tubing method the cement is pumped into the well through tubing after circulation has been established. To prevent the cement from rising between the tubing and the casing suitable packing devices are used. The tubing method may be used either with or without a plug between the cement and the wash water that is pumped into the well to carry the cement up on the outside of the casing.

The casing method is more or less a variation of the tubing method and practically amounts to using the casing itself instead of the tubing. This method may also be used either in conjunction with one or two plugs between the cement and the water or without suitable barriers separating the cement and the water.

Asphalt As Well Sealing Material.—Asphalt has not yet been widely used for sealing water wells, but this material offers a special advantage in sealing wells that yield water under artesian pressure. In using cement the movement of the water must first be prevented, as otherwise the cement will wash away and will not form a tight seal. Asphalt, however, even before it sets, is impervious to water. When the heated asphalt comes in contact with water the outside of the material takes a partial set while the inside portion remains in a more or less fluid state. By controlling the temperature and the pressure under which the asphalt is placed, openings which con-

tain water in motion can be tightly sealed, thereby preventing the entrance of pollution into the well or the loss of water under artesian pressure.

It would appear that some of these methods might be used to good advantage in Indiana and would largely prevent the contamination of waters of good quality. Some of them can also be adapted to overcome contamination in wells that have been completed for some time. Every such well, however, must be considered as an individual problem, and thorough study should be given to all the factors that bear upon its solution.

Acknowledgment.—The above is an abstract of a paper presented March 21st at the joint meeting of the Indiana Water Well Drillers and the Indiana section of the American Water Works Association. It is published with the permission of the Director of the United States Geological Survey.

Pumps Hung from Cables Dewater Dam Site

Pumps suspended from cables stretched across a canyon were used by the General Construction Co., of Seattle, Wash., to remove water from the site of the dam now being constructed at Owyhee, Ore. The construction of the Owyhee dam is a $17,000,000 project undertaken by the government in the extreme eastern part of Oregon, near the border of Idaho, in Malheur County. This involves the building of a concrete dam across the Malheur River to a height of approximately 250 ft., having a length at the crest of some 1,500 ft. and backing up the river for 52 miles. The stored water will be used to irrigate a large fertile area extending from Nyssa, Ore., to Ontario and Vale, covering some 120,000 acres.

The diversion of the river necessitated the construction of a tunnel 25 ft. in diameter and 3,000 ft. long through solid rock. With this completed and the river diverted from its old channel, it was necessary to remove the water remaining at the dam site in order to begin construction of the dam foundations.

Two electrically-operated pumps were furnished for this purpose by the Byron Jackson Co., each a No. 3-A Deepwell unit with 6 ft. of column and direct-connected to a 75-hp. General Electric induction motor. These pumps were suspended on cables stretched across the canyon, and were raised and lowered by means of a winch situated on the platform where the pump was mounted. General Electric magnetic control was used to start and stop the pumps, push-button stations being placed on the platform where the pump attendant was stationed. This made it unnecessary to mount heavy starting equipment on the platform, which had to be raised and lowered to meet the water conditions encountered.

The two pumps together handled almost 5,000 g.p.m. As one pump discharged through a 500-ft. line of 10-in. pipe, the friction from this and from a gate valve in the line brought the total head on this pump close to 120 ft. As a result the 75-hp. pump motor was constantly overloaded, handling a load of 90 hp. Conditions were better at the other pump, whose motor had but a 45-hp. load. The overload on the first pump was corrected by the installation of a medium-capacity impeller.

Fold Blueprints "Face Out"

When folding blueprints for filing, it is a good plan to fold them "face out." By doing this, time will be saved in searching for a print. In most cases the print can be folded so that the title will show, however, a glance at the outside will usually identify the print if one is at all familiar with it. A possible disadvantage of folding prints this way is that a portion of the print is more easily soiled, but this is not an important consideration unless the print is to receive rough handling.

Left—General View of Canyon at Owyhee Dam Site. Pumps Are at Work in Sump Close to Dragline. Right—Close-Up of Two Dewatering Pumps. The One in the Foreground is Pumping Out the Hole and Discharging into the River Below the Lower Cofferdam. The Other Is Connected to a Hydraulic Nozzle Which Is Used for Sluicing Earth and Loose Rock Off the Canyon Walls.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
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Washing Rates for Rapid Sand Filter Beds

In discussing the washing of filter beds it is realized that this is a subject in which there is probably more differences of opinion than most anything else in connection with rapid sand filtration. How to keep such beds in good condition has perplexed filter operators from the very beginning of this type of filtration and more especially since the abandonment of mechanical rakes years ago when we began to build rectangular filter beds. Taking the sand out of beds that are in bad condition, breaking up the clogged places, and restoring the beds to good condition, only to let them get bad again and then repeat the procedure, is not a solution of the problem. Yet this is what we see done in the majority of the rapid sand filtration throughout the country.

Efforts to Solve Filter Bed Troubles Have Not Been Along the Right Line.—It does not seem to have occurred to many that they have been working along the wrong line in attempting to solve filter bed troubles. Almost every kind of filter bottom conceivable has been offered by someone as a solution of the problem, and yet we are not much better off in regards to the solution of filter bed troubles than we were when the first filtration plants were constructed. In fact, we are worse off than when mechanical rakes were used. There seems to be an opinion firmly fixed in the minds of practically all filter plant designers and operators that someone will eventually design a filter bottom that will keep the sand beds in good condition regardless of the water being filtered. If one will give the matter a little more intelligent thought it is believed that we can see this is impossible. What are we trying to do when we wash a filter? If it is to cleanse the bed of the suspended matter which has been filtered from the water, then what are the factors that will produce the maximum cleansing? Some types of filter bottoms very likely will give better distribution of the wash water than others, but an even distribution of the wash water is not going to solve filter clogging troubles in most of the filtration plants. If there are defective bottoms in some plants, replacement of the bottoms with better ones should result in improvement in these plants, but this does not mean that the beds are going to keep in good order if there is any material tendency to clog. A bottom of the proper design is one essential, but it is only one of several essentials. What we have been trying to do heretofore is to solve the filter clogging problem by working almost exclusively on one of the essentials that in reality was solved almost at the beginning of rapid sand filtration, that is, even distribution of the wash water.

Character of the Water Has Greatest Influence on the Tendency of the Filter Beds to Form Clogged Places.—It should be evident from the various articles published by the writer that he regards the character of the water as having great influence on the tendency of the filter beds to get in bad condition. There may be two plants in which everything is equal except the water, yet the condition of the sand beds in the two plants may be quite different. Neither aluminum hydroxide nor ferric hydroxide alone will adhere to sand grains with a force that cannot be knocked loose with very slight agitation of the sand. It is the presence of other compounds naturally in the water that causes the coatings to form. In most instances organic compounds are the chief source of trouble. Some organic jellies will build up on the sand grains so toughly that it will require a force probably one hundred times greater to remove than is required to remove precipitates of aluminum hydroxide. Where there is manganese in the water the coating may be built up still more toughly. This is why some of the best operated filtration plants in the country have excessive filter clogging troubles.

Where standard practice has been followed in the design and operation of a filtration plant and there is considerable trouble from filter bed clogging, it is not the filter bottom, size of sand, rate of wash, nor the coagulant used, but it is mainly the character of the water that produces the trouble. These factors, if deviating from customary practice, may have an influence, especially the size of sand and rate of wash; however, such factors do not vary enough in most plants to account for the great difference in the tendency of the beds to clog. With coarse sand and a high rate of wash a greater cleansing force can be produced than with finer sand and a lesser rate of wash. With the same kind of filter bottom and using the same kind of coagulant, some filter beds with sand of 0.35 mm. diameter for the 10 per cent size and a washing rate of 15 gal. per square foot per minute will keep in good condition while others with sand of 0.5 mm. diameter and a washing rate of 20 gal. will get in very bad condition. The cleansing force with the coarse sand and higher rate of wash is much greater than the finer sand and lower rate of wash. In fact it may be two or three times as much, yet it is not sufficient to keep the beds in good condition when filtering waters of certain characteristics. In the face of such facts, is it not time that we direct our efforts to solve filter bed troubles along lines that produce a greater cleansing force?

More Agitation of the Sand Needed.—The agitation of the sand grains must be sufficient to knock loose most of the solid or gelatinous matter adhering to the grains and to break up all masses of coagulated matter to a size that it is washed away with the wash water. The only thing the filter bottom can do towards keeping the bed clean is to distribute the wash water uniformly under the bed. When this is done it is everything a filter bottom can possibly do, and any bottom that does this is just as good as another bottom. The promoters of the patented types of bottoms of course believe they have the only bottom that actually gives even distribution of the wash water. Some of these bottoms probably are better than others in giving good distribution of the wash water, and the better types should be used; but if one bottom produces a 5 per cent better cleansing effect due to better wash water distribution than another, and it requires a cleaning force four times greater for one bed than another to keep them in good order, certainly the 5 per cent difference is a

long way from accomplishing what is desired.

Increasing the Washing Rate Produces Greater Agitation.—A washing rate that puts the sand just in motion produces a certain cleansing force that may be sufficient to keep the beds in some plants in good condition. It is evident that the size of the sand grains, their specific gravity, and the temperature of the water influences the amount of water necessary to put the sand in motion. The finer or lighter sand being near the surface it is put in motion with a lesser rate than the coarser sand near the bottom, and a washing rate that puts all the sand in motion gives the beds an expansion of from 15 to 20 per cent. Increasing the washing rate over the minimum to just put all the sand in motion may increase slightly the rubbing or abrasion force, but it increases the motion of the sand grains or the agitating force quite materially and causes the sand grains to strike each other more frequently and with greater force. A rate is eventually reached in which additional wash water applied from underneath the bed probably will not increase the tendency to knock the suspended matter loose from the sand grains, though the higher rate will wash away more of the small mud balls or masses of coagulated matter.

The farther the sand grains are spread apart in washing over that necessary to give considerable agitation, the less will be the scrubbing effect. The grains may be in a more rapid state of motion, but they have a greater distance to travel to strike other grains. The point where the cleansing effect due to scrubbing or abrasion is actually reduced in a filter bed probably is a washing rate higher than now generally used. There is no way of actually measuring the scrubbing force produced by washing a sand bed and definite values cannot be set. When the wash water is all applied from underneath the beds, as is the case for practically all filtration plants, it seems probable that the maximum rubbing force (the actual pressure two grains press against each other as their surfaces rub) is produced when the bed is just in a state of fairly good motion, though the more rapid motion of the grains at higher rates may actually scrub off more of the adhering matter even if the scrubbing force is a little less.

The agitating force may be assumed to be the force at which the individual grains are moving about and knocking against each other. This force increases as the rate of wash increases, though not in a direct ratio of the increase. When the bed is put just in motion the movement of the grains is very slow and they do not strike each other so often nor with a very great force. As the bed becomes expanded greater the grains are at a greater distance apart and have a chance to gain some momentum before they strike other grains. Friction of the water prevents more than a certain force being produced, unless the water itself is put into a state of considerable turbulence. It is evident as the bed becomes more and more expanded that a point is reached in which fewer grains are striking each other than if it was not expanded so greatly. In other words, a rate can be produced in which the agitating force is actually reduced as well as the scrubbing force, though this point is probably at a much higher washing rate than for the maximum scrubbing force. When the tendency to cleanse the sand grains is compared on the basis of the wash water used, there is a maximum cleansing effect at a certain rate which will vary considerably with the size and specific gravity of the sand grains, temperature of the water, and the tendency of the suspended matter to adhere to the sand grains. Experiments indicate this maximum to be a washing rate higher than is now generally used.

Experiments at Baltimore.—When the writer perfected, in 1923, the first glass tube filter used extensively for experimental work, many observations were made on washing filter beds. The glass tube filter showed that for small size tubes, rates of washing greatly in excess of what was being used at that time in large filter beds could be used. It was not until a rate of about 35 gal. per square foot per minute was reached that the fine gravel became disturbed. A rate of 17 gal. had been used in the large filter beds at Baltimore for several years prior to this, and we were aware that the beds would stand a higher rate than this when in good condition. Experiments were run on a few of the large filters in the plant in which the wash water valves were opened wide. The writer does not have a record of the rate this gave, but he is under the impression it gave about 19 to 20 gal. per square foot per minute. When the beds were in good condition we saw no ill effect from the high rates, but this rate did not prevent clogging. As there was considerable danger of disturbing the gravel when clogged places formed, we returned to a rate somewhere near 15 gal. The significant fact of the Baltimore work was that there appeared to be nothing that could be done in the way of increasing washing rates or time of wash that had a material influence on reducing the clogging tendency of the filter beds. Rates as high as have recently been suggested were not used, but we did use rates high enough to give a sand expansion approaching 50 per cent. The Baltimore water has a great tendency to cause filter bed clogging and there is no size sand and no rate of wash within the bounds of what may be used that will prevent clogging in this plant.

Experiments at Detroit.—The most recent contribution to our knowledge of washing filters has been made by Hulbert and Herring [1] at Detroit. They recommend washing at a rate that will give about 50 per cent expansion of the sand bed. Setting the sand expansion as the guide for determining the rate of wash to be used is probably a distinct advance over present methods, though the writer is of the opinion that such a guide will never be used as a routine procedure. About the best we can expect is for the various filter plant operators to determine about what sand expansion they would like to have and set their wash water valves or washing rates accordingly. Even this will be a distinct improvement over no guide.

Study of Filter Washing Rates.—To see if there is any justification for the 50 per cent sand expansion as recommended by Hulbert and Herring, considerable study has been given to filter washing rates. Figure 1 shows tests on a typical filter sand with a glass tube filter about 1¾ in. in diameter. It will be noted that the expansion is nearly a straight line function of the washing rate, the expansion starting at a rate of about 7 gal. per square foot per minute for the particular sand used. It also will be noted that just before enough wash water is added to start the bed expanding there is an actual shrinkage of the bed. This is due to the sand grains working themselves together to form a smaller void area. This probably will occur to a much less extent in a large bed where the wash water cannot be cut off rapidly.

It required a washing rate of 7.5 gal. to put a little of the top sand in motion with the sand used to produce the curves illustrated in Fig. 1. At a rate of 15 gal. per square foot per minute, which is approximately 24 in. vertical rise per minute, there was an expansion of 6 in., or nearly 25 per cent. Most filter beds are now being washed at this rate; however, most of them probably have finer sand and there is greater expansion. With 6-in. expansion the movement of the sand was very slow, but the entire bed was in motion. It was evident the maximum agitating or even cleansing force was not reached with this rate for the grains did not have free movement and they merely rubbed slowly against each other. In fact the agitation was very little compared with what it was at higher rates.

It is not possible to measure the agitating force produced in washing filters in terms of something that can be plotted on a diagram like the expansion of the bed. About the only thing one may do is to rate the agita-

[1] Studies on the washing of rapid sand filters. J. Am. Water Works Assoc., 21:11, 1445-1513, November, 1929.

tion as none, little, fair, considerable, etc. Assuming the point where maximum agitation appears to be produced by applying all the wash water underneath the bed to be 100 per cent agitation, a curve might be plotted by assigning certain percentages of the maximum for lower rates of washing. In the glass tube filter with the particular size sand grains and depth of the bed, the maximum agitation of the sand appeared to be when the washing rate was about 30 gal. per square foot per minute, or approximtaely 48 in. vertical rise per minute. At 15 gal. washing rate the agitation appeared to be only about 10 to 15 per cent of the maximum.

It must be remembered that there are two forces tending to cleanse the sand—agitation, and sand grains rubbing against each other. As stated, the rubbing force probably is greatest when the sand is just in fairly good motion. Even though this force may be considerable, very slow motion of the grains would take a long time for the sand to be cleansed of the adhering matter. The curve for the agitating force shown in Fig. 1, while only approximate, is not greatly in error. The force at least varies in the general direction of the curve. It will be noted that 50 per cent agitation was obtained at a washing rate of about 20 gal. per square foot per minute. Now it would seem unwise to stop at 20 gal. when by increasing the rate to 23 gal. the agitation is increased to about 75 per cent of the maximum. Perhaps the curve is a little overdrawn and it does not rise so rapidly at the middle point. What is intended to bring out with the curve is the fact that about the middle point of agitation the force is increasing at a more rapid rate than the expansion.

Fifty Per Cent Sand Expansion a Very Good Criterion for Washing Filter Beds.—With the particular sand used in the experiments illustrated in Fig. 1 it was not until there was 35 to 40 per cent expansion before the grains began to have a movement independent of the surrounding grains. At lower rates the sand moved more or less together, not like it was bound together but the motion of the grains were not independent of the surrounding grains. The writer's observations point strongly to the 50 per cent sand expansion suggested by Hulbert and Herring as producing about the desired agitation for good cleansing of the bed. These remarks refer to agitation only, and it must be remembered that the scrubbing or abrasion force drops off as the sand grains are forced farther apart. It is likely, however, that this force has not dropped off materially at 50 per cent sand expansion. The fine gravel begins to be disturbed at a washing rate of about 35 gal. per square foot per minute when the temperature is about 15° C., and the washing rate should not approach this too closely. With sand less than 0.4 mm. diameter for the 10 per cent size it is likely that a sand expansion of 50 per cent or slightly greater may be used without danger of disturbing the gravel, providing there are no clogged places in the bed. With larger size sand a less expansion should be used, but the scrubbing or abrasion force of the coarser sand is greater than the fine and the bed may have an even greater cleansing force.

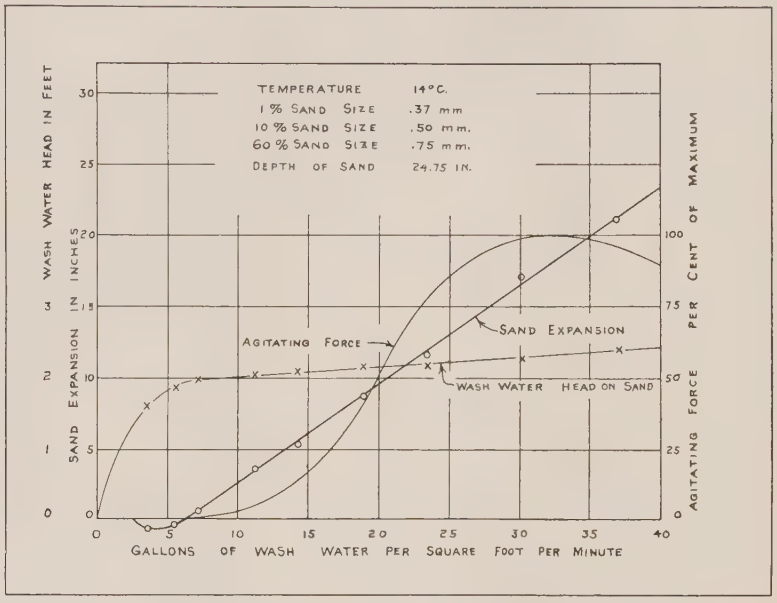


Fig. 1—Tests on a Typical Filter Sand.

The motion of the sand in a large filter bed being washed is really a series of boils, the water and sand rushing upward in places and downward in other places. Until there are fairly long tests on large size filter units the writer believes it would be unwise to use washing rates much in excess of 20 gal. per square foot per minute, or approximately 32 in. vertical rise per minute. This happens to be almost exactly the rate suggested by Hopkins [2], which was determined in another manner. In the face of what the agitating curve shows for 23 gal. per minute it would seem that one might risk this rate where the tendency to clog is fairly great, yet it is evident that such a rate would be disastrous to a bed with clogged places.

It Is Not Possible to Wash at a Rate That Will Keep Filter Beds in Good Condition When the Tendency to Clog Is Great.—Chief consideration in this discussion has been given to the factors producing the maximum cleansing force in sand beds where all the wash water is applied from underneath. Whether or not this maximum cleansing force, if it were possible to apply it, will keep the sand beds in good condition for all plants in the summer months is doubtful. The writer does not believe it will, even for the majority of filtration plants. By using washing rates that will give a maximum cleansing force, perhaps 25 to 30 per cent of the filter beds within the United States could be kept continuously in good condition, and those of many others could be kept in better condition than they are now being kept. This would be a marked improvement over existing conditions, but a long way from the ideal.

Additional Force Is Necessary to Keep Filter Beds in Good Condition.—For the past 6 or 7 years the writer has been advocating the solution of filter bed clogging troubles by the application of a force that will keep them in good condition almost regardless of the clogging tendency of the water. So far no one seems inclined to resort to anything other than applying the wash water underneath the beds. The work at Baltimore and more especially the excellent work of Hulbert and Herring at Detroit calls attention to the fact that not enough force is now being applied into the beds. The writer feels that he is on the right track with the surface wash and that something of this nature will eventually have to come into use. If it requires a certain washing force to keep the sand beds of a filtration plant handling a certain water in good condition and it is not possible to apply the necessary force from underneath the bed, what would you do? What we are now doing is to let the beds get in bad condition and then restore them to good condition by digging out the clogged places and washing the sand by some expensive method. As has been stated, this merely corrects a bad condition only to let it get bad again. Surely this is not the solution of filter bed troubles.

[2] Control of washing at rapid filtration plants. Eng. News-Record, 102: 841, May 23, 1929.

Charges for Standby or Breakdown Service

A Discussion of the Principal Factors Entering into the Entire Rate Structure

By J. C. STIPHER

Indianapolis Power & Light Co., Indianapolis, Ind.

THE effect of a maximum demand on a system is not the same with all utilities: the railroad company furnishes its service at stated hours, the telegraph company furnishes its service not instantly, but in the order in which messages are received for transmission, the telephone subscriber must wait until the connection is completed; whereas, there must be sufficient capacity ready at all times to supply gas, water and electricity, which must be delivered at the very moment the consumer chooses to use it, and as long, and no longer, than he pleases to use it.

Factors Governing Cost of Service.—Accordingly, the central station and distribution system must be of sufficient size to meet the maximum load of the entire system. This is specially true in the matter of electric energy in that there is no practical manner in which any large amount can be stored. It is evident, therefore, that the cost of serving should be governed by factors other than that of the actual energy used by each consumer. There are three recognized factors which should enter into the establishment of rates for service; namely, demand cost, output cost and consumers expense.

Demand cost, is the fixed charges on the cost of that portion of station equipment, transmission lines, transformers or substations, real estate, buildings, etc., used and useful in supplying the maximum requirements of the consumer, also, a certain portion of the general expense, taxes and depreciation. In other words, it may be classed as rental charge for the equipment necessary to take care of the consumers maximum load.

Output cost, is the cost of the energy used by the consumer and consists of the cost of fuel, oil, water, labor and supplies incidental to power-house operation.

Consumers expense, is the cost of reading meters, billing and collection expense, new business expense and consumers premise expense.

Charges Shoud Have Relation to Cost.—In considering a proper compensation for service the charge rendered should, as far as practical, bear relation to the cost of rendering it. If it is a matter of competition it will solve itself, for a utility cannot for long supply classes of consumers at a loss and recoup that loss by exorbitant profits from other classes of consumers.

It is clearly to the advantage of the utility to obtain as its patrons those whom it best pays to serve and to provide such means as are practical to compensate those consumers whose operations and usage are of benefit to the system of the utility. On the other hand, it is equally important to both the utility and its consumers in general that in so far as practical, the utility receive a proper compensation from those consumers whose short hours of operation are such as to necessitate a capacity expense not commensurate with their usage.

Inasmuch as the central station cost is one composed largely of fixed charges and is not materially affected by the quantity of the product sold, the cost of the product delivered to the consumers premises is affected more by the hours use of the maximum demand, or load factor, than by any other factor.

Situation of Fixed Capital Costs.—Prior, therefore, to the establishment or readjustment of rates the utility ascertains the amount of interest and other fixed charges on the property and equipment used and useful in the supplying of service to its patrons. The fixed capital costs thus established are allocated and distributed to the various classes of users on its system, using as a basis for such allocation its experience and records as to what percentage of such costs is chargeable to each particular class. Thus is established the demand cost, previously referred to.

The output cost and customers expense, the remaining factors which enter into the ultimate rate, are established in a like manner, however, these costs unlike the demand cost, though averaged, would not reflect any great difference whether consumers were treated as a class or individually. This procedure is equitable to all concerned, in that proper consideration is given to diversity factor, or the ratio of the sum of the maximum demands of a given group of consumers at different times, to the actual maximum demand by the group at one time, and at this time it may be well to emphasize the fact that the Central Station Industry is dependent for its existence on diversity and demand factors.

Forms of Rates.—There are many forms of rates in use throughout the country, such as: Flat rate (no meter), uniform meter rate (flat rate per unit of measurement), meter rate based on quantity of consumption, meter rate with a minimum charge, meter rate based on hours use of maximum rated capacity and rates varying with time of day at which service is used, etc.

All of such rates are established using as a basis the average operating conditions and average cost of serving a certain class of consumers. In other words, a class of consumers is considered and treated as a whole and the rate per unit of measurement and/or the block of the rate as well as the minimum charge are so constructed as to insure a fair and reasonable return to the utility.

Under such forms of rates the costs of serving, or fixed capital costs, are as a rule included in the first block of the rate. There are advantages and objections to each and all of such forms of rates particularly as pertains to flat rates. The one objection to each and all of such rates is, that the consumer whose operations are helpful to the system, must help carry the consumer whose operations are harmful and in some instances must help carry those who are served at a loss to the utility.

Primary Objectives of Rate Schedule.—A rate schedule should have three primary objectives; First, to secure a satisfactory profit for the utility, second, to develop the sales of the utility's product, by discouraging the use of private plants and other sources of supply, developing new uses for its products and improving the load factor of its system by improving the load factor of its individual consumers. The third objective is to prevent discrimination by providing rates so constructed that each class of consumer, and when practical, each consumer will bear a proper share of central station costs.

Inasmuch as the demand cost, or as it is sometimes termed, readiness to serve cost, is the principal factor in the cost to the utility supplying gas, water and electricity and is not materially affected by an increased consumption, it should be given primary consideration in the establishment of rates for service. That this method of charging for service is practical is evidenced by a review of rate schedules of electric utilities, throughout the country.

At the present time the form of rate which comes the nearest to fulfilling the objectives referred to, is the demand or demand and energy rate.

The Demand and Energy Form of Rate.—This as the name implies, is composed of two separate and distinct charges; namely, a demand charge and an energy charge, and each is essentially as much a part of the ultimate charge for service as the other.

To participate in, or benefit by this form of rate, it is necessary that the operations of the consumer be such that his load factor, or hours use of his maximum or billing demand be greater than that of the average consumer, for if otherwise, the cost to him for such service would be less under a form of rate not having the Demand Charge feature.

Establishing the Demand Charge.—There are a number of methods employed throughout the country in dedetermining the demand and in establishing the demand charge under the demand and energy from of rate; some of which are as follows:

Demand as contracted for and limited by a demand limitator.

Demand based on rated capacity of consumers equipment.

Demand based on rated capacity of transformers installed.

Demand based on instantaneous peak indicated by watt-hour meter or recorded by graphic instrument.

Demand based on integrating peak of 5, 10, 15, 30, etc., minutes duration, as shown by installed demand meters.

Demand based on average of two or more of the integrating peaks, referred to.

In analyzing these methods you will note that some would tend to curtail the size of the installation and thus retard further use and development, invite fraud, provide compensation for a demand, that may, but has not yet been demanded.

The intent of the method adopted should be to establish a charge for service in the same manner that it would be determined if the consumer was installing a private plant of the exact size necessary to supply the demand created.

The last two methods; namely, demand based on integrating peaks of certain duration, and the average of such peaks, are the methods more generally employed at the present time.

If the method adopted for the determination of the demand involves the installation of demand meters, or entails added expense to the utility, the demand schedule should be protected by a minimum charge providing a sufficient amount to insure the costs of determining the necessary demand information.

The next angle involved in applying the demand schedule is as to whether the billing demand, once established, shall apply only during the month such demand was created, or shall it continue for twelve months or until exceeded by the demand of a subsequent month.

The Measure or Billing Demand.—The basis of practically all business is annual, rather than monthly, and the manufacturer or merchant fixes the prices of the goods he sells on the basis of his annual overhead charges and costs of doing business and which apply in the good season, as well as in the bad.

In a case before that body the Public Service Commission of Indiana said, "In the operation of Electric Utilities it is also noteworthy that all electrical engineers of recognized ability recommend the kilowatt Demand Charge, which is in reality a Ready to Serve Charge applied to consumers of electric current, based on capacity required.

In the year 1924 this Commission made a very thorough investigation of the Ready to Serve, or Demand Charge applying to electric Utilities, with a view of eliminating it, however, very weighty argument, by those familiar with its application succeeded in convincing the Commission of the fairness of the Demand, or Ready to Serve Charge and that it should not be disturbed."

In another case the same commission defined the measured or billing demand as the greatest average rate of consumption of electric energy used by a consumer for fifteen consecutive minutes within the period of one year.

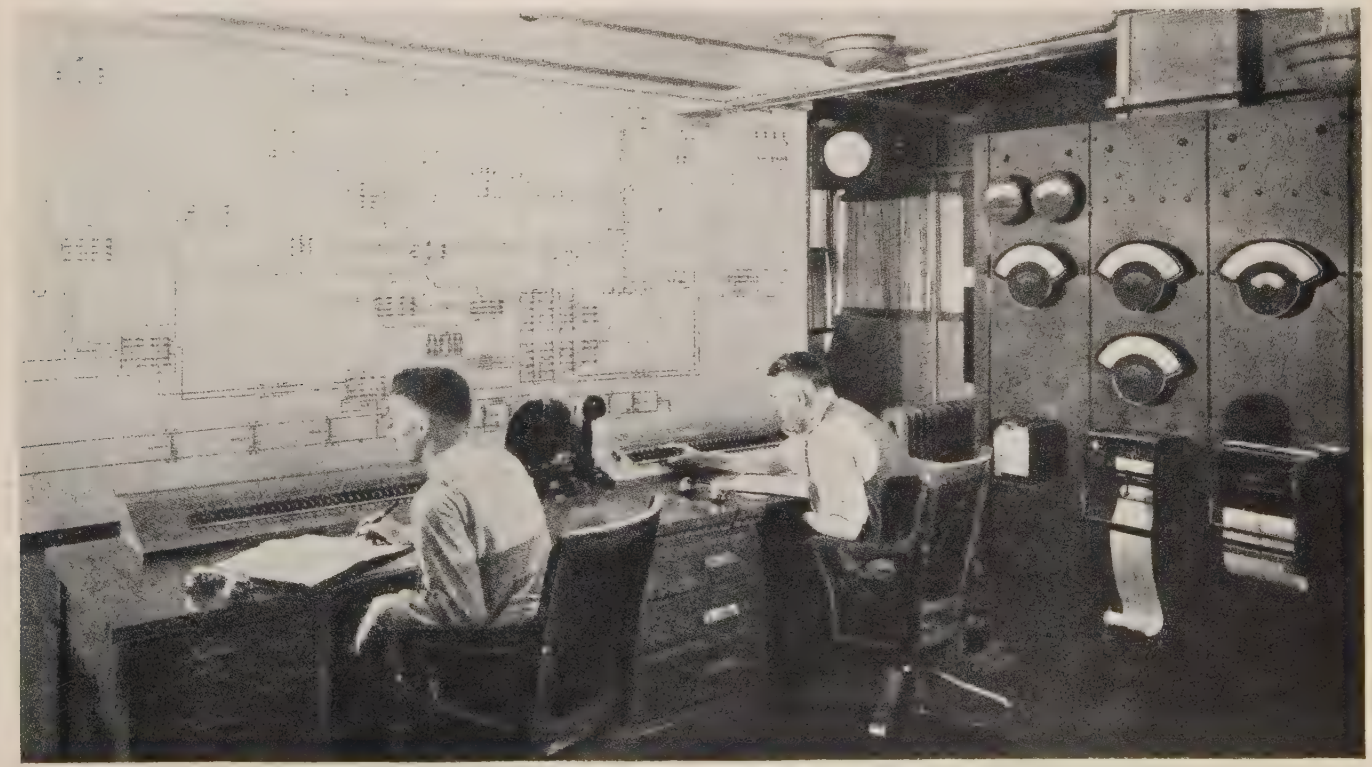
The principle of this demand or ready to serve charge is not only universally recognized as being sound, but it has been repeatedly approved by state public service or utilities commissions throughout this country.

The prime purposes accomplished in the use of the demand and energy form of rate is that it insures a proper compensation for standby, breakdown, or auxiliary service and thus enables the utility to properly compensate the consumer whose load factor reflects to the betterment of the entire system.

In other words, so to speak, the demand and energy form of rate places the consumer on his own feet and ultimate charges are commensurate with his operations.

Typical Example.—The following example and which is typical, emphasizes the fairness of this form of rate:

"A" has connected and in use coincidentally 2-300 H.P. motors loaded



Headquarters of System Load Dispatcher of Hydro Electric Power Plant of City of Los Angeles, Calif.

to capacity and thereby establishing a demand on the company's system of (600 H.P.X .746 KW) 447.6 KW. He uses this demand of 447.6 KW one hour per day, establishing a daily consumption of 447.6 KWH or (447.6 X 360 days) 161,136 KWH per year.

"B" has connected and in use coincidentally 2-50 H.P. motors loaded to capacity and thereby establishing a demand on the company's system of (100 H.P. X .746 KW) 74.6 KW, he uses this demand of 74.6 KW six hours per day establishing a daily consumption of (74.6 X 6 hours) 447.6 KWH or (447.6 KWH X 360 days) 161,136 KWH per year.

Accordingly, "A" has six times the demand of "B," but it is in use but one-sixth the number of hours that "B's" demand is in use.

The total yearly consumption for each is identical, namely, 161,136 KWH per year. The total yearly costs for electric service to each under a block energy rate would be the same, thus providing no incentive for a longer hours use of the demand and no penalty for an abnormal demand.

Under the demand and energy form of rate consumer "M" and "B" would pay the same amount for energy, but in addition each would pay a ready to serve, or demand charge proportionate to the cost to the utility supplying his demand requirements. The demand cost to "A" would be six times as great as the demand cost to "B," and this is as it should be:

In conclusion, follows an abstract from an opinion of the Public Service Commission of Indiana, in a case before that body, *"While there are weeks and months in which many large users of electricity may not consume any current, it would be unjust and unfair to require the Public Utility to be prepared at all times to furnish them such service without applying the Ready to Serve Charge, known as the Kilowatt Demand, based on capacity."*

Acknowledgment.—The foregoing is an abstract of a paper presented at the annual meeting of the Indiana Section, American Water Works Association, at Purdue University, Lafayette, Ind., March 20 and 21.

Unusual Core Wall in Australian Dam

The core wall of Silvan dam No. 1 for the new water supply of the city of Melbourne, Australia, according to the "Commonwealth Engineer," is particularly interesting. The drainage system is built integral with the wall and is of an unusual type, consisting of a series of vertical wells constructed monolithically in the wall itself near the downstream face, communicating with a collecting and inspection gallery near the bottom of the wall, below the natural surface of the ground. The wells are 3 ft. in diameter and are spaced 4 ft. 6 in. on centers along a line 2 ft. 6 in. from the downstream face of the core-wall structure. The inspection gallery below the line of the wells is 2 ft. 9 in. wide and 5 ft. 6¾ in. high, of semi-oval section, with a flat footway and a side drain 9 in. wide and 9 in. deep. Each well communicates with this gallery by a 6-in. galvanized-iron pipe set in the concrete. The gallery drain discharges at its lowest point into the tunnel which carries the outlet pipes from the reservoir. Weepholes, spaced 4 ft. 6 in. on centers along the length of the gallery, are provided for draining from the earth fill on the downstream side of the core wall. Similar weepholes are provided at intervals in each of the drainage wells. Access is obtained to the inspection gallery by means of shafts from two of the wells that are equipped with ladders, near the ends of the dam.

The theory of action of this drainage system is that any cracking of the wall that might occur and might allow leakage will almost certainly break into a well and not pass through the solid concrete between wells to the downstream face of the wall. Periodical inspection of the lower ends of the pipes in the gallery will show whether water is coming into any of the wells. If the amount of water appears at all considerable, the well can be opened by digging down from the crest of the dam and removing the concrete cover with which each well is equipped. A detailed inspection can then be made down the whole depth of the well, and any cracks can be dealt with in an appropriate manner. Should the crack and leakage be serious the well concerned, and possibly those adjacent to it can be filled with concrete, and the wall thus strengthened at this point. Thus, in effect the well system provides a ready means of inspection of the behavior of the whole wall, and of quick access to any part that may be giving trouble. It is believed that this is the first time this system has been used in any part of the world.

The real core wall may be considered as that portion of the structure in front of the line of wells. It is 1 ft. thick at the top and increases in thickness to a point below natural ground surface on batters of 1:60 on both sides. The wall, together with its drainage system, has reinforcement placed 6 in. from both upstream and downstream faces, consisting of meshes of ½-in. mild steel rods spaced at 12-in. centers vertically and horizontally. In constructing the wall it is poured in the usual manner between forms, and the drainage wells are molded by means of cylindrical wooden moving forms which are drawn up by stages as the wall rises.

Extensive use is being made of mechanical appliances in the construction of the dam. An aerial ropeway, 3¼ miles in length, conveys sand and cement from the nearest railway station to the dam. The ropeway carries 100 buckets of 7-cu. ft. capacity, and each bucket travels the length of the line in just under one hour. The system is driven by a 40-hp. electric motor and is capable of moving about 130 tons in eight hours. Stone is quarried about 2 miles upstream from the dam site and brought in on a narrow-gauge railway. Concrete is mixed at the ropeway and railway terminals and transported to the core wall in a 6-ton skip running on a cableway 2,000 ft. in length.

Material for the fill is excavated by steam shovels working at three locations, both upstream and downstream from the dam, and transported by means of narrow-gauge equipment. The fill is spread by tractor-drawn scoops and consolidated by steam rollers. There are four Cletrac and five Caterpillar tractors on the work, and the general practice is for each tractor to draw two scoops which pick up the material as it is dumped from the trucks and spread it where desired. By this means the earth fill is spread in layers from 6 to 8 in. deep, and each layer is consolidated by rolling before the next is spread. An Ateco hydraulic dirt-mover has been recently put on the work of spreading, and this promises to be far more efficient than the scoops.

The steam rollers used for consolidating the spread material are 8, 12 and 15 tons in weight, and are equipped with special deeply-grooved rollers. The grooving of the rollers aids the consolidation, not only in giving an even distribution of pressure, but also in leaving a rough surface that provides good binding with the next layer.

Silvan dam No. 1 will contain 1,670,000 cu. yd. of rolled earth fill and 60,000 cu. yd. of concrete.

Ohio Conference on Sewage Treatment

The 4th annual Ohio Conference on Sewage Treatment will be held Oct. 16 and 17 at Dayton, O. The executive committee of this year's conference includes the following: Floyd G. Browne, Marion, chairman; T. C. Schaetzle, Akron, vice chairman; M. W. Tatlock, Dayton, secretary-treasurer; O. F. Schoepfle, Sandusky, member-at-large; F. D. Stewart, Columbus, editor.

The Ohio Conference on Water Purification will be held the same week as that chosen for the sewage conference, as is customary, for the convenience of those desiring to attend both meetings.

Dayton is served by a new sewage treatment plant, which was put into service last fall. This plant will be of interest to all members of the conference, not only because it includes some new and novel features but also because of the excellent landscape treatment of the plant site. Those attending are assured a hearty welcome by the officials of the city.

Relation of Public Utility to Customers

A Practical Discussion of the Many Considerations Entering Into the Everyday Business in the Water Works Field

By JOHN A. BRUHN
Sales Promotion, Indianapolis, Ind.

ONE of the distinctions between public utility business and other kinds of business is the peculiar duty or obligation to serve the entire public attached to the former. A typical statutory direction to public utilities with respect to service reads:

"Every public utility shall furnish, provide, and maintain such service, instrumentalities, equipment, and facilities as shall promote the safety, health, comfort, and convenience of its patrons, employes, and the public, and shall be in all respects adequate, efficient, just, and reasonable."

It is probably true that no other business in the country carries such broad responsibilities.

Sound Business Practice Essential.—The management of a water plant is confronted with the problem of furnishing an abundant supply of purified water for domestic, commercial, and manufacturing purposes. To meet the requirements of each class it is necessary that the supply be free from water-borne disease germs, turbidity, and mineral content injurious to boilers or manufactured products; that the pressures be adequate and continuous; and the quantity available at every point be sufficient for ordinary, as well as fire protection purposes. For each endeavor there is a resulting cost. The business of the water company cannot be successfully conducted except in accordance with economic law and sound business practice.

We find in modern times the public buying many of its necessities without the power of discretion, or refusal being invested in the seller of such supplies; as for instance, water. Going further to the point, the terms and conditions under which such sales take place are largely outlined by the public through Public Service Commissions.

The company with which I'm connected—the Indianapolis Water Company—has for years been taking its task seriously—to furnish an adequate, dependable supply of purified water under satisfactory pressure at a reasonable and equitable cost. We are striving to profit by mistakes made and experience gained and to make as efficient as can be made possible the administration of the public water supply.

Importance of Satisfactory Customer Relations.—Customer relations is important to all business enterprises. It is conceded that honesty and frankness pay and that some effective method must be found to inform customers as to the nature of the services supplied. These efforts must be made by each utility company in the way best suited to the customer and to the mass psychology of the territory which it serves.

People are moved by actions and attitudes, plus facts which appeal to their imaginations and create confidence and belief. Public relations are truly satisfactory only when there is general confidence that the service rendered is all that can reasonably be expected, that the price charged for it gives a reasonable profit, and that the management is constantly alert to effect improvements in service. The purpose of public relations is to establish such confidence. It must be deserved and based on truth, frankness, and good performance.

Employees' Good Will Important.—A public utility needs the good will of its employees before it may have the good will of the public. That statement has been made and agreed with many times. Regular meetings of the employees, together with interest shown by the company in their welfare, tend to improve the attitude of the personnel toward the company and its management. In my comparatively brief association with the company I have been favorably impressed with the importance and value of the educational meetings held by the commercial department. At last month's meeting, attended by more than 50 members, careful consideration was given the subject "Our contact with the public." On one night three members of the department gave well prepared papers on various phases of the subject. "Efficiency in Meter Reading and Billing." On April 18 the evening will be spent on a study of the construction and operation of water meters. A chief contact for making friends with the customers is the company's employees. Careful attention should be given the human element in service. It sarcely needs to be said that the utility company should want all of its employees to be contented, happy, and prosperous for their own benefit, for the company's benefit, and for the public's benefit, as their health of body and mind is reflected in the quality of our service. Knowledge of this was the dominating factor why our company requires a thorough physical examination of all employees and firmly believe in group insurance.

Contacts with Customers.—Major public contacts between utilities and their customers generally develops along the following lines:

1. Applications for service.
2. Meter reading.
3. Commercial activities which include billing, collections, and disconnections.
4. Payment of bills.

A company's policies in regard to the above are obviously worth considerable attention.

In the rendering of public service it seems an unfortunate fact that it is apparently impossible to satisfy everyone, try as we may, because of changing conditions, additions of new personnel and the idiosyncrasies of certain customers. However it is our policy to give every consideration, courtesy and service the customer is entitled to and can reasonably expect.

Classes of Customers.—In our organization the customers are divided into three main classes. We have at the present time about 70,510 domestic accounts, which includes locations where water is used primarily for domestic purposes, approximately 670 industrials consisting of factories, railroads, laundries and places using water for industrial purposes, and 4,233 commercial customers by which term we mean stores, hotels, hospitals and other consumers not found in the two other classifications.

Naturally the amount of business or revenue received from the above cannot be the basis for rendering of service. Domestic customers because of their numbers and the nature of consumption, take up by far the greater part of the commercial department's time.

Signing Up the Customer.—The first impression made by the utility on its customer is at the time the contract is signed and is lasting. Therefore, the personnel of this contacting point should be carefully chosen. Our experience indicates that men with an efficient, courteous, and friendly manner, fill the position best. They need not necessarily be middle aged, but should possess mature judgment, a good education, and training, be self confident, have a good personal appearance and the ability to take a certain amount of abuse without becoming exasperated even when circumstances are trying.

Possibly the first impression is made when the customer calls to secure pre-

Laying 60-In. Water Supply Conduit from Filters to High Service Pumps, Indianapolis Water Co.

liminary information before coming to the office. The telephone operator's importance is frequently underestimated. She, and the phone desk clerks, must, of course, be able to hear well besides having an abundance of patience to deal with an irate customer having real or fancied wrongs, who has made up his mind to secure what he wants, whether right or wrong. It is necessary that the switchboard operator know the particular duties and personnel of various departments. In calling some business houses it is not an uncommon experience to talk to four or five persons before getting the proper one, especially if the call is concerning something a little out of the ordinary even though what was wanted had been clearly stated. Utilities are also frequently guilty of this inefficiency.

Prominence of Personnel.—Commercial activity and personnel are brought into more intimate contact with the public being served, than any other part of a utility working system. Recurrent meter reading, billing, collecting, investigating, etc., which logically are parts of the commercial end of the organization bring into inevitable prominence the part that personnel must play in the success or failure of the business. There is much truth in the statement of one writer who says: "One unwise move on the part of an employee can do more toward upsetting a utility's business routine than the breaking of a part of the physical system. Repair parts are available on a handy shelf. The same cannot be said regarding the sudden replacement of an uncoordinated part of a human mechanism.

We welcome inquiries made in good faith, for through them, and constructive criticisms of our present service, we will be able to render more efficient service in the future. Some time ago we ceased using the word "complaint" and substituted therefor the word "inquiries," it being our experience the majority of the people were desirous of making inquiry rather than registering a complaint. Some, however, are made where there is no apparent reason or cause, purely to get bills reduced whether justified or not.

Office Contacts.—Clerks and cashiers in the office are the chief contacts between customers entering the office, as are meter readers, inspectors, and district turn-on and turn-off men with the far greater number outside. Outstanding qualifications for the field men are a courteous, gentlemanly appearance, neatness and knowledge of his duties. We are trying to inculcate in the minds of these men the idea that they are representatives of the Indianapolis Water Company and not merely meter readers, clerks, or turn-off and turn-on men. They should have at heart the duty of service to the customer, as well as faithfully serving his employer.

Handling Delinquent Accounts.—In the matter of delinquent accounts and disconnections much can be said. Broad applications of hard and fast rules may react to the disadvantage of the utility both from the standpoint of relations and financial return. When a customer's service is disconnected there is no income, although the investment in equipment remains the same.

Collections are important, but shutting off a concern's service during financial stress may result in closing of the plant or receivership and bankruptcy along with the laying off of several hundred men who are then not able to pay their water bill. Drastic action on the part of the utility may result in unfavorable criticism from the stockholders and directors of the firm. It is oftentimes wise to get a true picture of the situation from banks, creditors, stockholders or directors of the company. Special reports from organized credit associations are valuable. Consideration must be given to the nature of the enterprise, its prospects, organization and management. The fact that the utility has given assistance to a firm in time of reverses cannot help but result in a friendly feeling on the part of the concern in question. Delinquent residential accounts are divided into three main classes. (1) Those inveterates who never pay until they are threatened with being turned off. (2) Those who are able to pay but through careless or indifference neglect to do so. (3) The ones who generally pay their bills promptly but who occasionally, on account of sickness or unemployment, are in a straitened circumstance for a short time.

For habitual delinquents a firm stand should be taken. They will have more respect for a utility if it follows its collections promptly.

The people of the second class are probably the hardest to deal with. They consider it a personal insult if service is denied them and insist their credit is good; that the utility need not worry if their bill goes unpaid for months. A personal interview or letter in their case is best, with an explanation why it is necessary to treat all consumers alike. However, the expense incident to this is almost prohibitive.

Extending Time on Delinquent Accounts.—The third class requires a great deal of sympathetic interest and attention on the part of the collection department. Those with a good credit standing of some duration should be given special consideration. Here is a good opportunity to create a friendly feeling for the company.

No hard and fast rules can be applied to the extending of time on delinquent accounts, and it must be left to the discretion and judgment of the head of the collection department. With this part of the commercial department lies the opportunity to increase favorable public relations. The customer owes it to his fellows to make prompt payment of bills so that the cost of collection may be held at a minimum. A heavy collection cost places an undue burden on all patrons of the company, the majority of whom are prompt in their payments.

Utilities in general, I believe, are beginning to realize that the introduction of a third party or guarantor is not conducive to good public relations. The securing of a deposit limits the

parties concerned to the customer and the company.

The hearty co-operation of all utility employees in the rendering of a courteous efficient service will so favorably affect public opinion that the resulting good will and friendly feeling will be a valuable asset.

High grade efficiency can scarcely be obtained through short term employees either in minor or supervisory positions. In our company the average service of regular employees is 10 years, and of the eleven department heads 34 years.

There are some persons so constituted that it is very hard for them to be fair or pleased with the best of service, but on the whole American men and women in the mass, are honest, shrewd, and fair, and will act just when satisfied they are being treated equitably and efficiently.

Making Adjustments.—As a general rule it is a poor policy to make adjustments because a service of value has been rendered at a cost and if this is not paid by the original customer it must be borne by other patrons who were in no way responsible for the excess consumption. Our duty is to serve the public. If special consideration is shown one man the same should be given all under the same circumstances. Discrimination in service and rates cannot be legally carried out. Some advocate special dispensations on rates for hospitals, religious enterprises, and educational institutions. The trend today is against this. There is no such thing as free water, any discrimination here must be borne by all customers.

Special Investigations.—The matter of just how far we can go in the furnishing of service to individuals at the expense of the public as a whole is a mooted question. Last December our meter readers made 552 special investigations to determine the causes of excess consumption. The average number made for each month of the year 1929 was 400. Reports were made on these. Each time a particular individual service is given operating expenses are naturally increased. This is excellent work but it also brings up the question how far in this we can go for the additional expense is carried by all.

Fairly definite rulings have been made as to the extension of mains, services, disconnections, flushing of mains, and the shutting off of sections while repairs are being made.

Customer's Part of Relationship.—Now concerning the customer's part in the relationship or interdependence between him and his utility. When a customer wilfully wastes unmetered water or makes surreptitious use of the service all of us know that instead of beating the water company he is ultimately raising the cost of service to other users, possibly including himself in future years. This holds good for water bills left unpaid as well. Likewise the person making unreasonable, unnecessary demands, consideration, or the laying of unproductive lines, places an unfair burden on the company and its other patrons. The non-modern property owner passes his share of the upkeep of the water works on to others because he does not comply with reasonable health rules by utilizing the city main in the street. The same principle applies to large industrial fire hazards. Insurance companies are but collectors and distributors and when there is a large economic loss through fire the cost is divided among premium payers. The attitude of mind so prevalent, which advocates the idea that as long as the insurance company pays—why worry, is certainly unthinkable from an intelligent standpoint.

The customer must be reasonable in his requests and remember that there are many thousands of other consumers who have the same right to ask what he does.

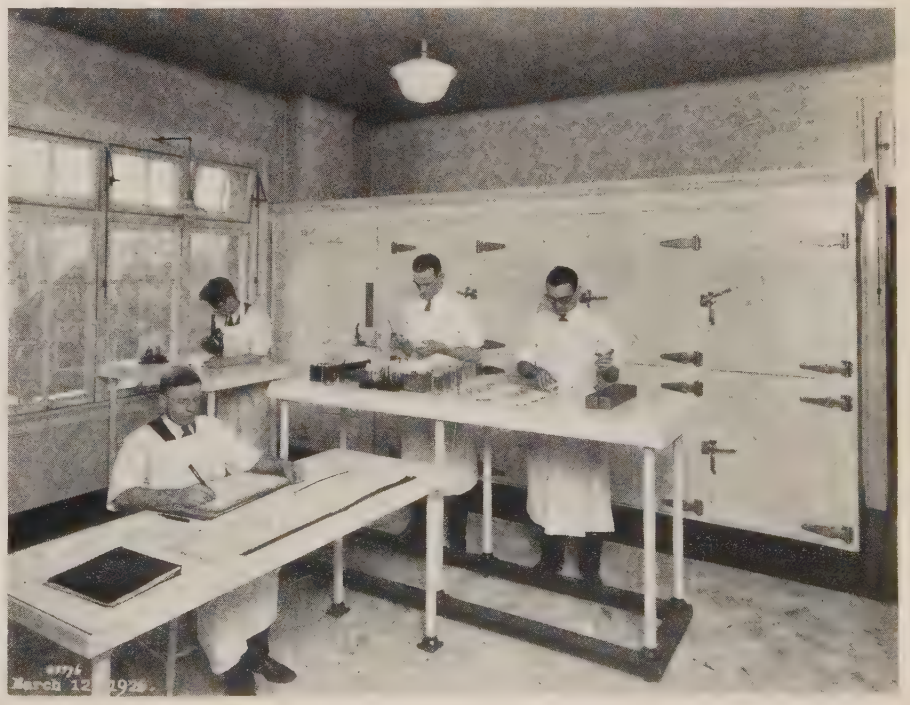
Our company has uniformed its meter readers for the benefit of its patrons and the company, and yet it is difficult for the men to keep themselves looking presentable because of the condition of basements and property in which they must go.

If the consumer is to expect the best of service at the lowest cost, he should remember that he can help materially by promptly paying bills, making arrangements for reading of meter if not home and by not expecting discrimination from the water company in the matter of adjustments, rates or services.

Assertions have often been made that utilities, and particularly water companies, are non-competitive. This may be true in one sense of the word; in others it is not exactly true. In Indianapolis the competition from private sources is very strong, especially among larger consumers, even though according to our rate scale most of them pay 6 ct. per hundred cubic feet. We estimate that more than one-quarter of the water used here comes from private supplies. Over 50 per cent of our pumpage of 34,000,000 gal. per day is sold to industries and commercial houses, therefore, our great dependence on them for business. The water company is called upon to furnish an adequate water supply for industrial and commercial enterprises and in all fairness they should pay their share of the cost of the public water supply service.

In its relations with its consumers and the public, the public utility corporation must deal with thousands of customers coming from all classes and in many cases its necessary rules and regulations will not meet individual wishes of some factory owner, store operator, or householder. Nevertheless it is perfectly possible for the utility to shape its policies and practices so that it may have and hold the good opinion of the very large majority of the public.

In an article I read some time ago, a writer expressed the opinion that public utility executives should sit behind the desk less and stand on the platform or at the luncheon table oftener. The more executives mix with people, the more contacts they will have and will become known as human beings just like other people. Good public relations do not depend on overstating the virtues of a corporation, but on calling attention to good work done.



Safeguarding the Water Supply—Bacteriological Laboratories, Indianapolis Water Co.

The idea that public utilities, as well as other large businesses are automatic, mechanical, cold, abstract organizations, driven by an arbitrary and remote power, has long been prevalent. This impression, along with attendant criticism of the utility, and other large business concerns, probably in several instances has not been without foundation.

The policy of some has doubtless been cold, automatic, and unthinking. Impersonal, indifferent treatment given customers results in advantage to no one.

Through experiment and systematizing in a personal rather than an impersonal way and in the application of human rather than mechanical principles toward the solution of problems, an organization can be developed which, though imperfect as human machinery must of necessity be, have certain advantages unattainable by more inflexible methods.

Many trivial complaints or inquiries will always be received but they should be given courteous, helpful consideration, for usually in the mind of the person who originates the inquiry it is entirely justifiable. Small accounts mean much to people of meagre means. A part of the cost attributed to time consumed by these many small inquiries might be allocated to good-will, that intangible item which is allowed a place as an asset on the balance sheet of private business—why not then on the balance sheet of public enterprises.

The law imposes on us the duty of furnishing a dependable, adequate purified water supply under satisfactory pressure at fair and reasonable rates. It should be our ambition to do more than that. Some have said that no acceptable work can be done in this world without a certain infusion of idealism. And we are not ashamed to admit that we have ideals, and try to convert them into accomplishments.

Acknowledgment.—The foregoing is an abstract of a paper presented March 20 before the Indiana Section of the American Water Works Association.

Adequate Financial Records Important

The following interesting discussion of the value to the water works operator of complete information on costs was given by W. C. Hail, Senior Public Accountant, The League of Kansas Municipalities, in a paper presented Feb. 13 at the Kansas Water Works School:

"Water is as free as air," is an expression frequently heard during an early period of municipal water plant operation when a general change from the old flat rate to the present meter system of selling water was taking place.

It was not an uncommon occurrence for prominent and successful business men, whose opinions were respected, to endorse the old wholly impractical and wasteful method of selling water on a flat rate basis. Why? Because a city's water supply was then considered as having little or no commercial value.

Increasing general property tax levies and bond issues for the support of our municipally owned water plants were perhaps the main factors in bringing about a change in public opinion regarding the commercial value of a city's water service.

A number of years ago a well known plant superintendent, in reporting to the city governing body on the subject of inadequate water rates, said in part —"It has been a matter of common knowledge for years to all who have been familiar with the water department affairs that the rates under which we are operating are not sufficient for the needs of the department. All of the water is now sold at less than cost and some classes of consumers are paying considerably less than cost. This can only be done, of course, by meeting the deficit by general taxation. At present we are levying taxes and paying the interest and sinking fund charges on water works bonds, and in many cases making repairs from bond issues. Thus carrying a proportion of the repair cost into the general tax levy."

No one believes that deficits of privately owned public utilities should be met by general taxation, and the same reasoning holds good for municipally owned public utilities.

It is now a recognized fact that fundamentally the purification, distribution, and sale of water are important commercial undertakings and the water plant operators in every community, regardless of its size, are or should be impressed with the importance and value of keeping adequate and accurate records of the production and plant operating costs. The information made available through the operator's records, if complete, is of the utmost importance in determining the cost of furnishing water. It is a comparatively simple matter to determine the cost of producing and maintaining any commodity if quantity production is established and adequate cost recorded through a master meter. Such a meter should be standard equipment with every water plant operator.

In this discussion it should be understood that the general suggestions pertaining to plant operators' records are considered as supplemental records to be used by the chief accountant to tie in with other major items of expense in supplying city water, such as general expense, distribution and line costs, repairs and replacement expense, interest and amortization of outstanding indebtedness.

The quantity of water pumped into the mains daily may be readily and accurately recorded through a master meter. Such a meter should be standard equipment with every water plant operator.

The unit cost requirements will of course vary in different communities, according to the methods employed in producing water, but as a general rule the operator is concerned with the cost of plant operation and maintenance. A simple and practical plan of recording such costs is by means of a monthly inventory report showing the quantity and cost of fuel oil, lubricants, gaskets, waste, packing, tools, engine repairs, and all other plant operating costs.

A definite and accurate record of the total cost of plant operation and quantity of water pumped is very essential and the most important factor in establishing a rate making basis and in determining the financial showing made by the water department each year.

Who's Who in Engineering

The American Engineering Council announces the appointment of a committee to co-operate in the publishing of a new edition of "Who's Who in Engineering." The function of the committee, according to Lawrence W. Wallace, executive secretary of the council, is "to provide such advice on the qualifications of engineers as will enable the publishers to issue a work which shall be authoritative."

The members of the committee are:

R. F. Schuchardt, chief electrical engineer, Commonwealth Edison Company, Chicago; John S. Conway, Washington; Dr. Harry A. Curtis, Department of Chemical Engineering, Yale University; C. R. Dooley, Standard Oil Company, New York City; Colonel Frank M. Gunby, associate, Charles T. Main, Inc., Boston; Arthur Huntington, Iowa Railway and Light Corporation, Cedar Rapids, Ia.; B. A. Parks, Byron E. Parks & Son, Grand Rapids, Mich.; Dr. H. S. Person, managing director, Taylor Society, New York City; Dean A. A. Potter, School of Engineering, Purdue University, Lafayette, Ind.; George S. Rice, chief mining engineer, U. S. Bureau of Mines, Washington; F. F. Sharpless, consulting engineer, New York City; Robert Sibley, executive manager, California Alumni Association, University of California; Major Brehon B. Somervell, district engineer, U. S. Engineer Corps, Washington.

The committee represents membership in the following societies:

American Institute of Chemical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Agricultural Engineers, American Society of Civil Engineers, American Society of Mechanicial Engineers, Grand Rapids Engineers' Club, Society of American Military Engineers, Society of Industrial Engineers, Taylor Society.

Iron Removal at La Porte, Ind.

Operating Results and Costs at Water Purification Plant

By C. C. FOUTZ
Superintendent Water Works, La Porte, Ind.

THE iron removal and purification plant at La Porte includes an aerating device consisting of 64 "Sacramento" type nozzles, discharging above a concrete "splash tray." The water flows to the center, whence it drops through a duct, nearly to the bottom of the aeration basin, which is a concrete reservoir 60 ft. in diameter and 20 ft. deep. The water rises in a diverging flow to a metal wier and conductor built around the basin and leveled to assure an equal flow at all points.

The effluent of this conductor goes to a mixing chamber, containing 5 horizontal passes, and 30 vertical baffles, and which discharges into the settling basin, which is a concrete reservoir 100 ft. in diameter and 24 ft. deep, with a baffle wall extending nearly across in a center line, so that water passes nearly around the circumference to a 24 in. cast iron pipe leading to the filters.

From the filters water passes to underground storage reservoirs from which suction pipes emerge.

The two concrete reservoirs referred to as the aeration basin and settling basin were formerly used as storage reservoirs and their cost is not included in the iron removal plant beyond the work required to convert them to the uses of iron removal.

The "raw" water supply is pumped from low duty station, 4½ miles from the city, directly through the aeration nozzles. The water flows by gravity from that point to filtered water reservoir.

Another View of the LaPorte Water Purification Plant

The "Sacramento" type nozzles have been very satisfactory, have been closed down and started and operated at 2 M.G.D. to 6 M.G.D rate and from 90 degrees above to 22 degrees below zero, with no difficulty. Considerable interest has been shown by engineers in regard to their performance.

Alum is introduced at center of aeration basin at the rate of approximately 80 lb. to each million gallons. This produces a good floc and seems to give best results. This alum is fed through a "Gaunt" dry feeder and carried in solution through a hose to the point of use by means of a steam ejector.

The detention periods are: in aeration basin, 7 hours; in settling basin, 19 hours. This is based on normal operation of 4 M.G.D. The total capacity of aeration basin is 1,200,000 gal., settling basin is 3,140,000 gal. while the filtered water storage is 1,500,000 gal.

Iron Content of Water.—The water coming to aerators varies greatly in iron content, and may be anywhere from 1.3 to 15 P.P.M. A typical colorimetric test for iron at the main points of operation is given.

	Unfiltered Samples P.P.M.	Filtered Samples P.P.M. (Filter paper used)
Raw water	6	3
Aerated water	4	1
Settled water	2	.6
Filtered water	.2	.2

This table indicates the proportion of iron removed by each operation. Filtered water shows .0 to .2 P.P.M. in daily test.

The Filter.—Four rapid sand filters are used, of 1 M.G.D. normal capacity. Each filter bed consists of 18 in. gravel in 5 grades and 36 in. of silica sand. The filters are equipped with rate of flow, and loss of head gauge, rate controllers and hydraulic operated valves.

The filters are operated as near full capacity as possible, average run on full load is 55 filter hours. The beds wash freely and an average wash of 5 minutes at 4,000 gal. per minute, a total of 20,000 gal. per wash, cleans them in good shape. We have no filter problem as the water is free from mud, silt, micro-organisms or growths, and only the iron is removed.

The Iron Removal and Water Purification Plant of LaPorte, Ind.

The Nozzles Discharging Above the Concrete "Splash Tray"

Wash water is supplied by a 40,000 gal. elevated tank, which is filled from distributing mains through a 4 in. service line.

Costs.—The cost of the iron removal plant, with connection to old pumping station are:

General contract	$123,695.92
Engineering and supervisor	10,852.71
Contingent costs	2,203.54
Total	$136,752.17

or $34,175.53 per M.G.D. capacity.

The operating cost for 5 months ending Jan. 31, 1929, were:

Operating labor	$ 701.40
Material and supplies	813.07
Interest and depreciation	2,647.45
Proportion of general expense	460.00
Wash water (filtered)	115.41
Wash water (unfiltered)	56.00
Total	$4,835.55

360,016,000 gal. were treated—.01343 per M. gal.

No full time labor is charged to iron removal, the duties of operation being distributed with steam pumping labor.

In comparing operating or production costs it should be remembered that these works are municipally owned, pay no taxes, or dividends and only interest on bonds issued for this purpose is considered, all of which would of necessity appear in a private or corporate owned property. The general expense is also very low, as office and other expenses are divided with other city departments.

Analysis.—The following analysis by the Department of Chemistry, Indiana State Board of Health, and taken from reports by Mr. L. S. Finch, Chief Engineer of the Board follows:

	March 1, 1929 P.P.M.	Feb. 19, 1930 P.P.M.
Odor	0	0
Color	.15	0
Sediment	Slight	0
Turpidity	25	0
Nitrite	.005	.001
Nitrate	0.0	0
Total iron	1.3	.2
Chlorides	6	8
Alkilinity	220	230
Total hardness	314	242

Bacteriological data is same on both samples and reported as satisfactory. This indicates the removal of color, sediment, turpidity, reduction of nitrite, reduction of iron to a harmless point and a reduction of total hardness.

Results of Iron Removal.—The distributing mains and service pipes were extremely foul with iron deposits. Results began to appear immediately on starting the removal plant and the pipes cleared much more rapidly than anticipated and are now practically free from iron deposits, with the exception of valves and dead ends, which infrequently let loose small amounts of iron sludge, which appear locally for very short periods. The "Red Water" nuisance has, however, been overcome and the reaction of the consumers has been all that could be asked for. Even the "Doubting Thomases," of which we, of course, have our share, now admit the success of the operation.

The engineers for this work were Hoad-Decker-Shoecraft & Drury of Ann Arbor, Mich. The plant was designed under the supervision of R. L. McNamee, Principal Assistant Engineer, and Ralph Ehler, Staff Engineer of the same firm was resident engineer and inspector on the construction.

Acknowledgment.—The foregoing is an abstract of a paper presented March 21 before the Indiana Section of the American Water Works Association.

Weed Control on Reservoir Margins

According to the report of the Board of Water and Power Commissioners of Los Angeles, Calif., for the fiscal year ended June 30, 1929, all reservoirs in the San Fernando Valley District are now under complete weed control. To accomplish this, 300,000 gal. of fuel oil were used during the last fiscal year. This oil was applied as a mixture of one-third oil and two-thirds water, and was sprayed under pressure on all weed growths which made themselves evident above the high-water line of the reservoir and over the reservoir bottoms as the water receded. This treatment has been in effect two years now, and resulted in getting a 98 per cent kill of all weed growths, tulles and willows. This method has resulted in material savings from a maintenance standpoint, in connection with the sanitary control on the margin of these lakes, as well as giving the property a neat and pleasing appearance.

Water Resources of North Dakota

Better and more abundant water for the farms, ranches, villages, and cities of North Dakota is a possibility presented in a report just issued by the United States Department of the Interior under the title, "The geology and groundwater resources of North Dakota." Howard E. Simpson is the author. The study was made by the United States Geological Survey in cooperation with the North Dakota Geological Survey.

This report also contains a discussion of the chemical character of the water, by Harry B. Riffenburg. It is published as Geological Survey Water-Supply Paper 598 and may be obtained from the Superintendent of Documents, Government Printing Office, Washington, for 50 ct. It sets forth in detail the results of an investigation covering a period of several years. The topography, climate, geology, and water supply of the state in general and of each of the counties are considered. The object of the investigation was to furnish to each community information showing the best ground-water supply available, whether artesian water can be found in that locality, at what depths water may be reached, through what formations the drill must pass, and what mineral compounds the water is likely to contain. The general availability and usefulness of the supplies are compared as to cost, purity, and permanence wherever the available data permit.

The book contains a map showing the several artesian areas in which flowing wells may be obtained, analyses of 196 typical waters representing the best supplies in every county of the state, and a table of the public water systems of cities and villages that have waterworks. The general descriptions of the rock formations and detailed discussions of the conditions governing the occurrence of ground water in each of the 53 counties are given. Because of the importance of the 7,000 flowing wells to the farming interests in this agricultural state, especial attention is given to the program for the conservation of artesian waters now being carried out under state legislation, a form of conservation in which North Dakota is doing pioneer work.

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Misnamed "Ethical Codes"

Several of the professions have adopted "ethical codes" in which minimum fees are specified. If a labor union adopts a rule as to minimum wages, it is not called an ethical rule, nor is there any more justification for regarding a doctor's or an architect's charges for services an ethical matter. It is economics pure and simple. Then why the camouflage? Well, perhaps because it is camouflage, but perhaps because consideration has not been given to the meanings of the words ethics and economics.

At the 1928 convention of the American Medical Association the delegates voted in favor of the following insertion in the ethical code: "The practice of medicine is not the proper function of corporations, and the American Medical Association should use its utmost endeavors to stop this growing abuse." Corporations are usually not ethical organizations. Medical associations never are; their prime functions are educational and economic. They undertake to enlighten their members and to make the practice of medicine more profitable. These two functions are quite distinct, and neither of them is ethical.

If medical corporations give service that is at least equal to that given by doctors in private practice, and charge less for the service, they will survive and multiply, for that has been the history of corporations in other fields. No appeal to ethical principles will prevail, for it is not an ethical matter.

From immemorial time advertising by doctors has been denounced as unethical. Just when does any practice become unethical? When and only when it injures a fellow being. False statements in an advertisement are clearly unethical; true statements are not unethical. Hence to brand all medical advertising as being unethical is a lie, and since broadcast lies are invariably injurious to some one, the prohibition of all medical advertising is itself an unethical practice.

Suppose that a highly successful surgical specialist were to publish his actual hospital record, and contrast it with the average record of all surgeons operating in the same hospital on similar cases; would that be unethical? Yes, according to the code of medical "ethics." No, according to any real code of ethics. Would such an advertisement injure his fellow men? Quite the contrary, for it would guide some of them to a surgeon more skilled than the average. And were he the possessor of the best record over a long term of years, it would serve admirably in showing to the public the most trustworthy specialist in a given class of surgery in their city.

However, were such advertising countenanced by the medical profession, it would speedily result in eliminating a large number of practitioners entirely, and this, we suspect, is one of the reasons why the medical "code of ethics" forbids advertising. The medical and surgical "dubs" far outnumber the really skilled members of the profession, and may be counted upon to vote down any resolution favoring medical advertising even where the advertisements are true.

The Alleged Superiority of Art Over Science

A year or so after Columbus discovered America, work was begun upon one of the greatest masterpieces in the realm of art, The Last Supper, by Leonardo da Vinci. Powers says: "The fact which it is important to bear in mind throughout our inquiry is that Leonardo was not primarily an artist, but a scientist. That was his own judgment, and one which inquiry confirms. * * * Leonardo regarded himself as an engineer, and the chief activities of his life were in this field. His attention was devoted largely to hydraulics, in connection with great projects of his various patrons. * * * He was scarcely less active, however, in military engineering, though a hater of war, while he ventured even into such untried fields as electricity and aeronautics. * * * His inventions include such familiar devices as the wheelbarrow and the camera obscura, the preliminary to modern photography. * * * That Leonardo is remembered not as a scientist but as an artist, is in accordance with a seemingly universal rule. Whenever an individual, a community, or a people, has achieved distinction in war, in government, in science, or in commerce, one or more, and at the same time in art, posterity has remembered the art and forgotten or minimized the other achievements. Athens was the greatest commercial power of the ancient world, but we remember only Homer and Plato and Phidias. Goethe thought that he would be chiefly remembered for his contribution to the science of optics, but the world forgets that he ever concerned himself with science. The value of science to humanity is incalculable, but it is significant that in longer perspective, where values are more justly estimated, it is art that the world delights to honor. The theft of Leonardo's (scientific) notebooks would scarce have won headlines in a paper, but the loss of the Mona Lisa startles and grieves the world."

Thus we are supposed to infer that art will always take precedence over science, that Archimedes must ever

bow to Homer. There is, however, a little matter that Powers and other writers on art overlook. Art was fully matured when Athens was in her glory. Physical science was born with Archimedes, and then was wrapped in swaddling clothes from which it did not emerge for seventeen centuries. Indeed Leonardo da Vinci was one of the very first to unwrap that infant and hold it up to public scrutiny. So we need not wonder that he was prouder of his camera obscura than of his Mona Lisa. It is a far-fetched logic, however, that deduces from such facts the conclusion that art is superior to science.

If, as Powers concedes, Leonardo's camera obscura was father to the photographic camera, it was grandfather to the moving picture, and therefore to the latest of arts. It needed only another scientist, Edison, to invent a sound recording device to enable dramatic art to step from the stage to the screen, and delight the world. Will such science be forgotten by posterity? Will they rank Goethe the poet above Edison the inventor? We doubt it.

Although science existed before the birth of Christ, it was as an embryo, and the vast majority of its conquests are less than a century old. How can one be so sure that when twenty more centuries shall have elapsed only the names of poets, artists, sculptors and dramatists will have survived the erosive effects of time? He is a bold prophet who foretells such an outcome, a very bold prophet and a very bad logician.

A Cure for Our Worst Economic Disease

Economic analyses made by the editor disclose that American per capita productivity is fivefold what it was a century ago. The buying power of the average wages has increased at the same rate as per capita productivity. Not only does this latter fact prove that socialists have been wrong in forecasting dire results from a continuation of the capitalistic system, but that labor unionists have been equally mistaken in their predictions that "the machine age" would enslave the worker and reduce his income.

By socialists and labor unionists alike one important fact has been overlooked. They failed to see that competition among employers would result in average "real wages" rising as fast as the average productivity of workers increased. Yet the U. S. census since 1859 has shown that manufacturing wages have been an almost constant percentage of the wholesale value of manufactured products. The same holds true as to the cost of raw materials used in manufacturing. The clear inference from these two facts is that profits have been almost a constant percentage of the value of manufactured goods.

Recently there has been a loud renewal of the century-old cry of fear that machinery is destined to deprive most workmen of jobs. The "robot" is pictured as a mechanical man who all but thinks; so it is prophesied that even the most skilled of workmen are doomed to be displaced by machinery. While it is true that ever since men entered "the machine age," about 150 years ago, machinery has displaced workmen here and there, it is equally true that machinery has coincidentally broadened the market for goods and has given to the average American an income sufficiently great to enable Americans to buy the increased output. Although this is usually admitted even by the pessimists, they are now arguing that the end of such an adjustment of production and income is in sight. Here again they fail to see that human desires are insatiable, and that so long as any desires remain unsatisfied production will continue to increase.

The great economic problem that lies before business men is to distinguish between those goods and services for which the demand is limited and those for which it is either unlimited or at least very flexible. Four pounds of food daily is all that the average human stomach can digest. Hence, so far as quantity of food is concerned, the demand for food in America can not increase faster than the population, or at the rate of about 1.5 per cent annually. On the other hand, there is an almost limitless demand for more expensive household furniture. We venture to say that few men or women go through the Huntington Art Gallery at San Marino, Calif., and view the magnificent tapestries, rugs, paintings and furniture, without wishing that they were the owners of at least some of it. In that wish lies the latent demand for better household furniture. By advertising and by "furniture shows" this latent demand is being slowly fanned into a great actual demand. No one can say what the result will be eventually, except that it will lead to the spending annually of many times as many dollars per capita for furniture as are now spent. It will require men and machines to make the furniture, and more men and machines to make the machines that make the furniture, and many men to sell both machines and furniture.

There is a limitless demand for amusement, as three industries have proved to the limit, namely, the motor car, the radio and the moving picture industries.

Even yet the motor car is primarily a pleasure giving device. Follow for a moment the result of its evolution. When the gasoline car began to appear frequently on our roads and streets in 1895, who would have dreamed that practically every American family would own one within 35 years? Even now how many of us seriously expect that the average American family will own two motor cars within the next 20 years?

A by-product of the motor car industry has been another industry in which more than two billion dollars are annually expended, namely, the great highway industry. Still another great by-product industry is the one devoted to the production and distribution of gasoline. Had it not been for the motor car, the building and maintenance of highways in America would still be a relatively small industry.

If more business men will learn to avoid trying to expand productivity in fields where latent demand is limited and where the production facilities are already more than adequate, and will direct their attention to fields where latent demand is great, we shall hear less and less of overproduction and the ills of the machine age.

H. P. Gillette

The St. Louis Convention of A. W. W. A.

ARRANGEMENTS are well advanced for the 50th annual convention of the American Water Works Association, which will be held June 2-6 at St. Louis, Mo. The preliminary program of the convention already has been announced. This program, which is subject to revision, is as follows:

MONDAY, JUNE 2, TO FRIDAY, JUNE 6, 1930
Hotel Jefferson, Headquarters

MONDAY FORENOON

8:00 Registration.
11:00 Governing Board.

MONDAY AFTERNOON

2:00 Plant Management and Operation Division and Superintendents' Round Table Discussion.
A. U. Sanderson, Chairman, Asst. Mech. and Elec. Engr., Department of Works, City Hall, Toronto, Ont., Canada.
2:00 Committee on Standard Methods of Water Analysis.
Jack J. Hinman, Jr., Chairman, Associate Professor of Sanitation, University of Iowa, Iowa City, Ia. Everybody welcome.

EVENING

9:00 Informal Reception and Dance.

TUESDAY FORENOON
Main Session

9:00 Opening of Convention.
Jack J. Hinman, Jr., President.
Announcement of Officers elected for the year 1930-31.
Reports of Secretary, Treasurer and Governing Board.
Action on Budget.
New Business.

TUESDAY FORENOON
Main Session (Continued)

Review of 50 Years Growth of the A. W. W. A.
Illustrated by Lantern Slides.
An outline of the growth of the Association and conspicuous water works developments during the past 50 years. Pictures of early past presidents will be shown.
Jack J. Hinman, Jr., President of A. W. W. A.
The Development of Railway Water Supply Practice.
Including an outline of the part played therein by the American Railway Engineering Association and the Boiler Feed Water Studies Committee, and touching upon points of common interest to railway and water utility officials.
C. R. Knowles, Superintendent Water Service, Illinois Central R. R., 6627 Woodlawn Ave., Chicago, Ill. Discussion led by J. B. Wesley, Engineer Water Service, Missouri Pacific Railroad Co., 1310 Missouri Pacific Bldg., St. Louis, Mo.; C. H. Koyl, Engineer Water Service, Chicago, Milwaukee, St. Paul & Pacific R. R. Co., 898 Union Station, Chicago, Ill.

TUESDAY AFTERNOON
Main Session

2:00 Recent Progress in the Art of Water Treatment.
Aiming to make available to the water works practitioner unfamiliar with technical details of water treatment, the important advances in recent years, that their benefits may be more widely applied.
Abel Wolman, Chief Engineer, Maryland State Department of Health, 2411 N. Charles St., Baltimore, Md. Discussion led by W. W. Brush, Chief Engineer, Department of Water Supply, Gas and Electricity, Municipal Bldg., New York, N. Y.; MacHarvey McCrady, Chief of Laboratories, Quebec Provincial Bureau of Health, 59 Notre Dame, East, Montreal, Que.
The purification of Highly Turbid Waters.
Including discussion of modern methods of preliminary treatment and operating experiences and with particular mention of the new Howard Bend Works at St. Louis.
John D. Fleming, Assistant Chemical Engineer, Water Division, 34 E. Grand Ave., St. Louis, Mo. Discussion led by L. B. Mangun, Chemist in Charge of Water Purification, Kansas City, Kans.; F. C. Duncan, Director, Bureau of Sanitary Engineering, Kentucky State Board of Health, 532 W. Main St., Louisville, Ky.; Dr. George F. Gilkison, Superintendent Filtration, Water Department, 5256 Brookwood Road, Kansas City, Mo.

TUESDAY AFTERNOON
Main Session (Continued)

Recent Water Borne Disease Outbreaks and Their Significance.
A recital of such occurrences pointing to the conclusion that unanticipated or unguarded sources of pollution are still common enough to make this problem highly important.
Abel Wolman, Chief Engineer, Maryland State Department of Health, 2411 N. Charles St., Baltimore, Md., and A. E. Gorman, Wallace & Tiernan Co., Inc., Newark, N. J. Discussion led by Robert Spurr Weston, Consulting Sanitary Engineer, 14 Beacon St., Boston, Mass.; George W. Fuller, Consulting Engineer, 170 Broadway, New York, N. Y.
Private Cross Connections and Similar Menaces to Quality of the General Public Supply.
Setting out the surprising commonness and variety of ways in which faulty arrangements on consumers premises may pollute an initially pure general supply.
Joel I. Connolly, Chief, Bureau of Sanitary Engineering, Chicago Department of Health, Chicago, Ill. Discussion led by William C. Groeniger, Consulting Sanitary Engineer, 503 Franklin Bldg., Columbus, O.; S. B. Morris, Chief Engineer, Water Department, 319 City Hall, Civic Center, Pasadena, Calif.; F. Gardner Legg, Sanitary Engineer, Detroit Department of Health, Detroit, Mich.; H. H. Gerstein, Sanitary Engineer, Department of Public Works, 8140 Drexel Ave., Chicago, Ill.

TUESDAY AFTERNOON (Continued)

2:00 Conference of Committee No. 19, Boiler Feed Water Studies.
Sheppard T. Powell, Chairman, Chemical Engineer, 213 St. Paul Place, Baltimore, Md.
(A group of appropriate papers, not yet definitely arranged for, will be presented. These will be itemized in the final program.)
6:45 Dinner, Water Purification Division. Social and Entertainment Features Under the Direction of the Inimitable William J. Orchard.

WEDNESDAY FORENOON
Main Session

9:00 History of Steel Cylinder Reinforced Concrete Pressure Pipe in Europe.
Major Peter C. Bullard, U. S. District Engineer, Duluth, Minn. Discussion led by F. F. Longley, Lock Joint Pipe Co., Box 21, Ampere, N. J.
Steel Trunk Lines with Bell and Spigot Joints.
William W. Hurlbut, Water Distribution Engineer, Department of Water and Power, 207 S. Broadway, Los Angeles, Calif.

WEDNESDAY FORENOON
Main Session (Continued)

Two Interesting Failures of Welds on Small Patches in Large Steel Pipe.
Illustrated by Lantern Slides.
A brief paper describing operating experiences with steel pipes in which holes cut for test specimens are closed with welded patches.
W. W. Brush, Chief Engineer, Department of Water Supply, Gas and Electricity, Municipal Bldg., New York, N. Y.
Cast Iron Pipe after 260 Years' Service in Gardens of Versailles, France.
Illustrated by Lantern Slides.
A brief paper describing the features of general interest in this historic installation.
Burt B. Hodgman, C. E., National Water Main Cleaning Co., 50 Church St., New York, N. Y.
Disaster Preparedness Plans for Water Works.
Dealing with the making of advance plans to meet possible catastrophes such as earthquake, flood or conflagration.
George W. Pracy, Superintendent of City Distribution Division, San Francisco, Water Department, San Francisco, Calif. Discussion led by E. L. Filby, Chief Sanitary Engineer, State Board of Health, Jacksonville, Fla.; John H. O'Neill, Sanitary Engineer, Louisiana State Board of Health, New Orleans, La.; S. B. Morris, Chief Engineer, Water Department, 319 City Hall, Civic Center, Pasadena, Calif.

WEDNESDAY FORENOON (Continued)
Water Purification Division

Frank E. Hale, Chairman, Director of Laboratories, Department of Water Supply, Mt. Prospect Laboratory, Brooklyn, N. Y.
9:30 Successful Application of Superchlorination and Dechlorination for Medical Taste to a Well Supply, Jamaica, N. Y.
Illustrated by Lantern Slides.
Unusual cause for Medicinal Taste probable. Short contact period for Superchlorination. Very simple control.
Frank E. Hale, Director of Laboratories, Department of Water Supply, Mt. Prospect Laboratory, Brooklyn, N. Y. Discussion led by Alan M. E. Johnstone, Manager, New York District, Wallace & Tiernan Co. Inc., 233 Broadway, New York, N. Y.; George R. Spalding, Asst. Supt., Filtration and Sanitation, Hackensack Water Co., New Milford, N. J.

WEDNESDAY FORENOON
Water Purification Division (Continued)

Progress in Superchlorination treatment for Taste Prevention at Toronto together with some studies on Chlorine Absorption.
Installation of one-ton containers and evaporators, effect of phenol on chlorine absorption in a polluted water.
N. J. Howard, Director of Water Purification, Island Filtration Laboratories, 410 Lake Shore Drive, Toronto, Ont. Discussion led by Linn H. Enslow, Research Engineer, The Chlorine Institute, Inc., 30 E. 42nd St., New York, N. Y.; Harry E. Jordan, Sanitary Engineer, Indianapolis Water Co., 113 Monument Circle, Indianapolis, Ind.
Chemical and Mechanical Utilization of Activated Carbon in Water Purification.
Illustrated by Lantern Slides.
Discussion of proper design and operation of suitable equipment, novel applications of activated carbon suggested.
A. S. Behrman, Chemical Director, and H. B. Crane, Principal Asst. Engineer, International Filter Co., 333 W. 25th Place, Chicago, Ill. Discussion led by Paul Hansen, Consulting Engineer, Pearse, Greeley & Hansen, 6 N. Michigan Ave., Room 1710, Chicago, Ill.
The Use of Activated Carbon for the Removal of Taste and Odor from Water.
Results of experiments with activated carbon of water containing taste and odors due to mixed industrial wastes.
George D. Norcom, Sanitary Engineer, Federal Water Service Corporation, 27 William St., New York, N. Y. Discussion led by Robert Spurr Weston, Consulting Sanitary Engineer, 14 Beacon St., Boston, Mass.
Further Observations on the use of Activated Carbon in Removing Objectionable Tastes and Odors from Water.
Illustrated by Lantern Slides.
Practical uses of activated carbon in filtration plants for dechlorination and removing objectionable compounds from water. Rates of filtration, depths of beds, methods for revivification.
John R. Baylis, Filtration Engineer, Bureau of Engineering, 1643 E. 86th St., Chicago, Ill. Discussion led by Charles P. Hoover, Chemist in Charge, Water Softening and Purification Works, Columbus, O.; W. A. Helbig, Chemist, Darco Sales Corporation, 45 E. 42nd St., New York, N. Y.

No papers will be presented Wednesday afternoon. Buses and guides will be available to take the members to the new Howard Bend plant of the city of St. Louis.

THURSDAY FORENOON
Main Session

9:00 Hydraulics of Deep Wells.
Dealing with the laws of flow into wells, mutual interference, economic spacing of wells and similar questions, including means by which existing data and theories may be made more useful than hitherto.
The late L. R. Balch, formerly of Mead & Seastone, Consulting Engineers, Madison, Wis. Discussion led by W. G. Kirchoffer, Hydraulic and Sanitary Engineer, 22 N. Carroll St., Madison, Wis.; Lafayette Higgins, Civil and Sanitary Engineer, 1144 W. 25th St., Des Moines, Ia.
Air Lift Pumps vs. Centrifugal and Other Deep Well Pumps.
Outlining the principal advantages and disadvantages of competitive means of pumping from deep wells with presentation of certion data on operating efficiencies and costs under service conditions.
C. N. Ward, Mead & Seastone, Consulting Engineers, Madison, Wis. Discussion led by A. P. Pigman, Mechanical Engineer, American Water Works & Elec. Co., 50 Broad St., New York, N. Y.; Major Thomas H. Allen, 1430 Bank of Commerce Bldg., Memphis, Tenn.
Importance of Proper Financing and Accounting in Water Works Practice.
A brief summary of the principal features in connection with finance and accounting and reasons why they are important, and outline of the aims of the new Finance and Accounting Division of the A. W. W. A.
H. Gordon Calder, Asst. Comptroller, Federal Water Service Corp., 27 William St., New York, N. Y. Discussion led by C. Van den Berg, President, Alabama Water Service Co., 1019 American Trust Bldg., Birmingham, Ala.; F. W. Schulz, Comptroller, Community Water Service Co., 46 Cedar St., New York, N. Y.
Mechanical Accounting for Water Utilities.
A general discussion with illustrative examples of the results obtained in certain water departments.
P. H. Hutchinson, Burroughs Adding Machine Co., 1 Park Ave., New York, N. Y. Discussion led by L. M. Anderson, Controller, Department of Water and Power, 207 S. Broadway, Los Angeles, Calif.; Hal H. Smith, Head Clerk, Water Consumers Accounts, Department of Water Supply, Detroit, Mich.

THURSDAY FORENOON
Main Session (Continued)

Problems of Water Utility Finance.
Contains suggestions as to handling various problems of water utility financing, including financing water main extensions.
A. P. Michaels, General Manager, Orlando Utilities Commission, Orlando, Fla. Discussion led by E. W. Agar, Superintendent Water Department, Valparaiso, Ind.; R. O. Drummond, Federal Water Service Corp., 27 William St., New York, N. Y.

THURSDAY FORENOON (Continued)
Water Purification Division

9:00 Some Neglected Dangers to Water Quality.
Attention called to other dangers than typhoid fever, such as parasites, resulting in serious difficulties in other countries though not yet in the United States.
Jack J. Hinman, Jr., Associate Professor of Sanitation, University of Iowa, Iowa City, Ia. Discussion led by Professor Edward Bartow, University of Iowa, Iowa City, Ia.
Unusual Color Removal Plant for part of the Los Angeles Water Supply.
Use of ferric chloride to remove color of 125 ppm., modified filtration unit for best results, new principle of "sludge return." Methods adopted to combat Crenothrix.
Carl Wilson, Laboratory Director, Department of Water and Power, Los Angeles, Calif. Discussion led by Linn H. Enslow, Research Engineer, The Chlorine Institute, Inc., 30 E. 42nd St., New York, N. Y.; J. S. Whitener, Assistant Professor of Sanitary Engineering, North Carolina State College, Raleigh, N. C.
The Trial Filtration Plant, Ottawa, Canada.
Trial filter justified by satisfying authorities and public that a colorless, tasteless water could be obtained at reasonable cost, by satisfying designers as to best methods. Operating personnel familiar with completed plant.
George G. Nasmith, Consulting Civil Engineer, Gore, Nasmith & Storrie, Confederation Life Bldg., Toronto 2, Ont. Discussion led by W. E. MacDonald, City Water Works Engineer, 21 Fourth Ave., Ottawa, Canada.
Prechlorination in Relation to Filter Plant Efficiency.
Illustrated by Lantern Slides.
Comparative experimental study at the U. S. Public Health Service experimental plant at Cincinnati over a period of 15 months.
H. W. Streeter, Sanitary Engineer, U. S. Public Health Service, Third and Kilgour Sts., Cincinnati, O. Discussion led by Linn H. Enslow, Research Engineer, The Chlorine Institute, Inc., 30 E. 42nd St., New York, N. Y.; Ralph A. Stevenson, Superintendent of Filtration, 3425 V St., Sacramento, Calif.

THURSDAY AFTERNOON
Water Purification Division (Continued)

Observations on Filter Sand Shrinkage.
A further account of what has been done at Detroit to discover cause and minimize trouble.
W. M. Wallace, Superintendent of Fltration, and Roberts Hulbert, Senior Chemist, Department of Water Supply, Detroit, Mich. Discussion led by Charles R. Cox, Asst. Sanitarian, Department of Health, Albany, N. Y.; Lyle J. Jenne, Sanitary Engineer, Bureau of Water, Department of Public Works, Philadelphia, Pa.
Manipulation of pH at Springfield, Ill., Water Purification Plant.
Illustrated by Lantern Slides.
Observations on sterilizing and coagulating values of excess lime, and practical application of flue gas at this plant.
Charles H. Spaulding, Chemist and Superintendent Water Purification, Department of Water, Light and Power, Springfield, Ill. Discussion led by John D. Fleming, Chief Chemical Engineer, Howard Bend Station, Water Division, St. Louis, Mo. (Route 25, Chesterfield, Mo.); Charles P. Hoover, Chemist in Charge, Water Softening & Purification Works, Columbus, O.

THURSDAY AFTERNOON
Main Session

2:00 The Advance Planning and Operating Results of Pumping Facilities at Chicago.
The studies and estimates involved in selecting pumping arrangements in relation to the results later obtained in service.
Loran D. Gayton, City Engineer, 402 City Hall, Chicago, Ill. Discussion led by L. A. Day, Water Commissioner, 312 City Hall, St. Louis, Mo.; W. C. Rudd, Asst. Engineer, Power, Department of Water Supply, 8100 W. Warren Ave., Detroit, Mich.; Leon Small, Superintendent Engineering Division, Department of Public Works, Baltimore, Md.
Wastefulness and its Correction in Operation of Pumping Stations.
Discussing the commonest sources of wastes in pumping stations and methods by which fuel costs have been reduced as much as one-half without replacing the main equipment.
A. P. Pigman, Mechanical Engineer, American Water Works & Elec. Co., 50 Broad St., New York, N. Y. Discussion led by L. A. Day, Water Commissioner, 312 City Hall, St. Louis, Mo.; A. D. Couch Mechanical Engineer Community Water Service Co. 46 Cedar St., New York. N. Y.; Kurt Toensfeldt, Combustion Engineering Corp., 200 Madison Ave., New York, N. Y.

THURSDAY AFTERNOON
Main Session (Continued)

Diesel Engines as Applied to Water Works Service.
Dealing with the extent of use, general status and principal features of interest of Diesel engines in water works service with some examples of operating results.
R. D. Hall, Manager, Water Works Sales, Worthington Pump & Machinery Corp., 2 Park Ave., New York, N. Y. Discussion led by F. G. Gordon, Consulting Engineer, Monadnock Block, Chicago, Ill.; Arthur L. Mullergren, Consulting Engineer, 770 Board of Trade Bldg., Kansas City, Mo.; A. D. Couch, Mechanical Engineer, Community Water Service Co., 46 Cedar St., New York, N. Y.
Obtaining Water Level Readings by Automatic Telephone.
A brief description of automatic devices used at Washington, D. C., to employ ordinary telephone circuits in transmitting water level readings from remote reservoirs to pumping stations.
Dewey M. Radcliffe, Associate Engineer, U. S. Engineer Office, Washington, D. C.
Business Meeting of Plant Management and Operation Division.

THURSDAY AFTERNOON (Continued)
Water Purification Division

2:00 Efficient Water Works Operation and the Purification Laboratory.
Illustrated by Lantern Slides.
Evaluates the Laboratory as an effective unit for economical efficient water works operation. Examples of Laboratory control producing considerable operating savings.
Martin E. Flentje, Superintendent of Purification, Supervising Engineers, Inc., 600 N. Second St., Harrisburg, Pa., and P. S. Wilson, Superintendent of Operation, Community Water Service Co., 46 Cedar St., New York, N. Y. Discussion led by L. T. Reinicker, Operating Manager, National Water Works Corp., 524 Washington St., Reading, Pa.; William U. Gallaher, General Chemical Co., 300 W. Adams St., Chicago, Ill.
Elimination of Taste in the Water Supply of Lancaster, Pa.
Experience with the use of ammonia with chlorination.
Edward D. Ruth, 135 S. Duke St., Lancaster, Pa. Discussion—

THURSDAY AFTERNOON
Water Purification Division (Continued)

Preammoniation of the Water Supply of Cleveland, O.
Large plant installation of ammonia equipment for eliminating taste and odor with chlorination. Point of application, dosage, etc.
J. W. Ellms, Engineer Water Purification & Sewage Disposal, Department of Public Utilities, Cleveland, O. Discussion led by Howard J. Pardee, The Pardee Engineering Co., 23-14 44th Road, Long Island City, N. Y.
Effects of Colloids on Coagulation.
Illustrated by Lantern Slides.
Colloids determined and nature studied in a colored and a turbid water. Effect of these colloids on coagulation requirement determined. Necessity of adjusting treatment indicated.
C. H. Christman, Filtration Department, National Aluminate Corp., 6216 W. 66th Place, Chicago, Ill. Discussion led by Thorndike Saville, Professor of Hydraulic and Sanitary Engineering, University of North Carolina, Chapel Hill, N. C.; Sheppard T. Powell, Chemical Engineer, 213 St. Paul Place, Baltimore, Md.
The Elimination of Coli-aerogenes Contamination, due to Pump Packing, from a High Pressure Centrifugal Pump.
Growth of Coli-aerogenes on pump packing.
Arthur F. Mellen, Filtration Engineer, Columbia Heights Filtration Plant, Minneapolis, Minn. Discussion led by Fred O. Tonney, Director of Laboratories and Research, Department of Health, 712 City Hall, Chicago, Ill.
Exhibit of Cyanide-Citrate Agar for Direct count of B. coli and B. aerogenes, with short description of improved simpler method of preparation.
Fred O. Tonney, Director of Laboratories and Research, Department of Health, 712 City Hall, Chicago, Ill.

FRIDAY FORENOON
Main Session

9:00 Training Operating Personnel for Small Purification Works.
Methods for instructing and directing non-technical operators and as a collateral subject the placing of small water and sewage purification works, where occurring in the same community, under a single technical head.
J. S. Whitener, Asst. Professor of Sanitary Engineering, North Carolina State College of Agriculture and Engineering, 1202 Cowper Drive, Raleigh, N. C. Discussion led by Abel Wolman, Chief Engineer, Maryland State Department of Health, 2411 N. Charles St., Baltimore, Md.; E. S. Tisdale, Director, West Virginia State Department of Health, Charleston, W. Va.; H. E. Miller, Chief Engineer, North Carolina State Board of Health, Raleigh, N. C.; Thomas R. Lathrope, Asst. Engineer, Ohio State Department of Health, Columbus, O.
Operating Experiences with a New Automatic Residual Chlorine Recorder and Controller.
Summarizing about one year's continuous

and successful operation with a new device at Little Falls, N. J., by which the residual chlorine content is automatically controlled and recorded.

J. Westford Cutler, Experimental Engineer, Wallace & Tiernan Co., Inc., Newark, N. J., and Frank W. Green, Superintendent of Filtration and Pumping, Passaic Consolidated Water Co., Little Falls, N. J. Discussion led by J. H. Harrington, Chemist, Montreal Filtration Works, Montreal, Que.

Development of a Water Distribution System for Greater Detroit.

F. H. Stephenson, Engineer of Water System, 735 Randolph St., Detroit, Mich. Development of a Water Distribution System for Greater St. Louis.

Thomas J. Skinner, Engineer in Charge of Distribution, 4600 McRee Ave., St. Louis, Mo.

These two papers relating to Detroit and St. Louis describe the means employed and the principles involved in comprehensive planning of distribution trunks and feeders with reference to present and future needs.

Discussion of two papers in common by Louis E. Ayres, Ayres, Lewis, Norris & May, Engineers, Cornwell Bldg., Ann Arbor, Mich.; J. B. Eddy, Engineer, Water Pipe Extension, 104 City Hall, Chicago, Ill.; V. Bernard Siems, Vice-President and Chief Engineer, National Water Works Corp., 11 Broadway, New York, N. Y.

FRIDAY FORENOON

Finance and Accounting Division

H. Gordon Calder, Chairman, Asst. Comptroller, Federal Water Service Corp., 27 William St., New York, N. Y.

A series of papers and discussions of interest to water works accounting officials, the details of which will appear in the final program, will be provided.

FRIDAY AFTERNOON

Main Session

2:00 Water Supply for Airports.

Dealing with the substantial quantity of water required for fire protection and the presence of unusually inflammable materials as related to the usually inadequate feeder supply to airports and the rapidly increasing number of such ports.

S. F. Newkirk, Jr., Superintendent and Engineer, Elizabethtown Water Co., Consol., 46 Broad St., Elizabeth, N. J. Discussion led by Clarence Goldsmith, Asst. Chief Engineer, National Board of Fire Underwriters, 222 W. Adams St., Chicago, Ill.; Herman Rosentreter, Engineer of Water Supply, City Hall, Newark, N. J.

Investigation of Service Pipes of Various Materials.

Dealing principally with friction loss tests with particular reference to the carrying capacity of copper tubing in comparison with other classes of pipe.

R. W. Reynolds, Superintendent, West Palm Beach Water Co., West Palm Beach, Fla. Discussion led by J. E. Gibson, Manager and Engineer, Water Department, 14 George St., Charleston, S. C.; S. H. Taylor, Superintendent, Water Department, 312 Municipal Bldg., New Bedford, Mass.; Seth M. Van Loan, Deputy Chief, Bureau of Water, 709 City Hall, Philadelphia, Pa.

Water Requirements of Cities in Arid and Semi-Arid Climates.

The effect of climate on requirements of representative western and southwestern cities having relatively dry or hot and dry summers, with special reference to irrigation needs.

N. T. Veatch, Jr., Consulting Engineer, 701 Mutual Bldg., Kansas City, Mo. Discussion led by Burton Lowther, Consulting Engineer, 723 Colorado Bldg., Denver, Colo.; V. M. Ehlers, Chief Sanitary Engineer, Texas State Department of Health, Austin, Tex.; Richard Bennett, Superintendent Water Department, Tucson, Ariz.

Sand Spun Pipe and Its Method of Manufacture.

Warren A. Brown, Engineer, R. D. Wood & Co., Philadelphia, Pa.

FRIDAY AFTERNOON (Continued)

2:00 **Finance and Accounting Division.**

A series of papers and dscussions of interest to water works accounting officials, the details of which will appear in the final program, will be provided.

Boring Machine Saves Cost of Trenching for Pipes

The accompanying photographs illustrate a machine for boring under paved roads to permit the installation of pipes, developed by the gas distribution department of the Rochester Gas & Electric Corp., Rochester, N. Y.

The machine, according to L. H. East, assistant superintendent of the gas distribution department, consists of (1) a boring tool varying from 3 to 8 in. in diameter; (2) a Ford differential mounted on a carriage, used to transfer the rotation of a vertical shaft into rotatory motion of the horizontal shaft and also as a speed reducer, and (3) a motor driven with air furnished by a portable compressor. The carriage runs on a plank track, and the machine is moved along the track as the hole is advanced.

This machine has found considerable use and has proved quite satisfactory for most types of soil. Holes up to 8 in. in diameter have been bored under 24-ft. pavements, through clay, hardpan and even clay containing small boulders. In the process of cutting a hole, the tool is fed in for a distance of about 2 ft., after which it is withdrawn and the earth removed. This operation is repeated until the width of the pavement has been penetrated. When working in hard clay, it has sometimes been found advantageous to bore a pilot hole about 3 in. in diameter first and ream this hole out with one or two reamers. Where the soil contains stone and small boulders, these obstacles can often be moved and turned so that they can be removed from the hole.

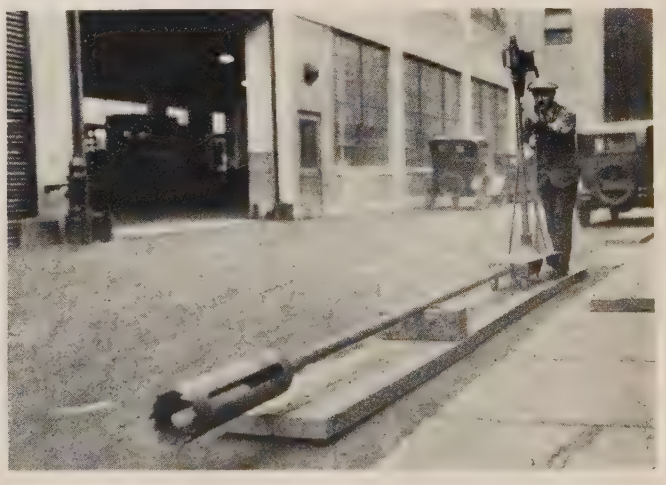
A Definition of Civil Engineering

For the purpose of the administration of the state act for registration of civil engineers, the State Board of Registration of California adopted the following definition: Civil engineering is that branch of professional engineering which deals with the economics of, the use and design of, the materials of construction and the determination of their physical qualities; the supervision of the construction of engineering structures; and the investigation of the laws, phenomena, and forces of nature; in connection with fixed works for:

Irrigation
Drainage
Water Power
Water Supply
Flood Control
Inland Waterways
Harbors
Municipal Improvements
Railroads
Highways
Tunnels
Airports and Airways
Purification of Water
Sewerage
Refuse Disposal
Foundations
Framed and Homogeneous Structures
Bridges
Buildings.

Furthermore, it includes:
City and Regional Planning
Valuations and Appraisals
Surveying, other than Land Surveying as defined in the General Laws of California, Chapter 247, Statutes of 1907.

Town Water Supplies in Virginia.—Of the 152 incorporated towns in Virginia, 83 have a town water supply.



Two Views of Pipe-Installing Machine Devised by Rochester Gas & Electric Corp.

New Books

"Water Supply Engineering," by Harold E. Babbit, Professor of Sanitary Engineering, University of Illinois, and James J. Doland, Assistant Professor of Sanitary Engineering, University of Illinois. First edition, 776 pages, 5¾ in. by 9 in., cloth hard binding. McGraw-Hill Book Company, New York, publishers. Price, $6.00.

The authors have produced a comprehensive treatment of water supply engineering in this work. They intended it to be used as a text book for civil engineering class work, but have gone entirely too much into detail except for a specialized course. Throughout the book they quote freely from their sources of information. This is a very commendable feature of the book. It is profusely illustrated, which is another excellent feature; especially where the book is used to teach the subject to students.

The authors state that the volume is not intended as a comprehensive treatise on water works, nor as a handbook, yet it certainly fills that bill to a great extent. The pure theory of water works engineering, if supplemented by examples in class work to illustrate the point under discussion, will leave the student more open-minded and receptive to new developments. The book is undoubtedly a valuable addition to the already rich supply of water works data.

"The Balancing of Engines," by W. E. Dalby, Professor of Engineering, Imperial College of Science and Technology, London. Fourth edition, 326 pages, 6 in. by 9 in.; cloth board covers. Longmans, Green & Co., New York City, publishers. Price, $8.40.

Since the first edition of this book was brought out in 1902 there have been great changes in the design of machines to which the theory of balancing applies, but the author's original method of solving balancing problems and of finding the balancing weights in a practical way on the drawing board has been found effective. In this fourth edition the method is continued, with amplification of the data and experience gained by research.

The number of machines for testing unbalance that have been brought out within the last few years is one measure of the importance now being given this matter by engineers. In automobiles the car buyer looks for something near perfect balance to give him freedom from vibration, noise, and excessive wear. Bridge constructors look for balanced locomotives to reduce the required allowances for hammer blow, torsional oscillation, and swaying. The designer of ordinary industrial machines must also balance the rotating parts if he is to obtain the quiet operation now demanded by the users. This book is an outstandingly complete treatise on the subject for the technical designer. It divides the subject into logical chapters, illustrating each with ample examples and drawings.

"Sewerage and Sewage Disposal," by Leonard Metcalf and Harrison P. Eddy. Second edition, 783 pages, 5¾ in. by 9 in.; cloth bound board cover. McGraw-Hill Book Co., New York City, publishers. Price, $6.00.

This is a revision of the book by the same authors which was put out in 1922. However, it has been built with the object in view of having it serve better as a text book. Even as it is, it is too voluminous.

The following table of contents gives an excellent idea of what is treated:

Chapter I—Introduction and general discussion.

Chapter II—Quantity of sewage, methods of predicting and estimating flow.

Chapter III—Quantity of storm water, how gauged.

Chapter IV—Hydraulics of sewers, flow of water, comparison of formulae.

Chapter V—Design of sewers, calculations necessary and economic considerations.

Chapter VI—Sewer appurtenances and special structures, discussion of equipment.

Chapter VII—Preliminary investigations, surveying and inspection.

Chapter VIII—Pipe and masonry sewers, properties, strength tests and joints.

Chapter IX—Load on sewers, live and dead, research investigations.

Chapter X—Excavation, sheeting and bracing of trenches, trenching machinery and underdrains.

Chapter XI—Characteristics and behavior of sewage, chemical and organic composition, bacterial action.

Chapter XII—Sewage disposal by dilution, pollution, purification and disease prevention.

Chapter XIII—Sewage disposal by irrigation, sewage farming, land treatment.

Chapter XIV—Principles of sewage treatment, sedimentation, precipitation and digestion.

Chapter XV—Screens, grit chambers and skimming tanks, detritus tanks and grease traps.

Chapter XVI—Sedimentation basins, sludge digestion tanks, principles of operation and design.

Chapter XVII—Sewage filters, loading, grouping, dosing cycles and equipment.

Chapter XVIII—The activated sludge process, principles of operation, degree of purification, pumps and agitators.

Chapter XIX—Treatment and disposal of sewage sludge, volumes to be handled, methods of disposing of remainders.

Chapter XX—Chlorination of sewage, disposal of industrial wastes, and choice of sewage treatment and disposal methods.

Chapter XXI—Financial considerations, estimating, construction costs and bond issues.

This comprehensive volume is made very usable by a set of problems at the end of each chapter.

"The Yardstick of Public Utility Operations and Construction Costs," by William W. Handy, Consulting Engineer. 1929 edition, 155 pages, 8¾ in. by 11¾ in.; paper board binding. William W. Handy, Munsey Building, Baltimore Md., publisher.

Trends during substantially the last two decades of public utility operations by means of ratios and construction costs, by means of indices is presented in the book in understandable style. They are used in connection with such matters as financing of extensions and acquisitions, investment in securities, purchase, valuation and rate cases. The data is used in analyzing and reporting on companies.

Part I gives curves of composite relations of all the major financial and operating factors having to do with the operations of twenty of the major gas and electric operating companies, as distinguished from holding companies. Practical examples of how these relations can be used in investigating and reporting on other companies is given.

Part II presents by means of index numbers the trends in unit costs from 1911 to Jan. 1, 1929, inclusive, of all major elements of construction entering into the building up of gas and electric utilities. The text explains how these trends can be applied in determining values of proportions at existing prices from historic or book costs.

This is a "yardstick" in that it presents a measure of construction values to be used in practice.

This volume should prove of value to investment bankers or members of their analytical and statistical departments interested in public utility properties, public utility engineers and accountants, public utility officials, regulatory commissions and their staffs, public utility attorneys and, generally speaking, all critical investors in public utility securities.

"Business Law for Engineers," by C Frank Allen, M. Am. Soc. C. E., M. Mass. Bar, M. Am. Ry. Eng. Assn., formerly Prof. of R. R. Eng. Mass. Inst. Tech. Third edition, 475 pages, 6 in. by 9 in., cloth binding. McGraw-Hill Book Co., New York, publishers. Price, $4.

This is a revision of previous editions of the same work, which consists in additions thereto. The author states that a more extended use of cost-plus contracts seems to justify a special chapter on the subject.

This book covers one phase of engineering and construction work about which executives are prone not to acquaint themselves. Engineers and contractors often get into difficulty and try to get out rather than take precautionary measures and avoid getting into the difficulty. One chapter on "The Engineer's Legal Relations with Others" should be digested by all engineers engaged in the profession.

Pipe Handling and Back Filling Unit

The W-K-M boom and side winch is now being manufactured for mounting on the Model DH Trackson McCormick-Deering. This equipment, which is made by the W-K-M Co., Inc., Houston, Tex., greatly increases the versatility and usefulness of the Trackson unit. With the W-K-M boom it is adaptable to backfilling, by the use of a throw-back bucket or Mormon board, pipe handling and laying, and other similar operations.

This combination of equipment is stated to lift and carry loads of 4500 lb. and will raise much heavier loads when stiff-leg is used.

The boom may be mounted on the tractor quickly and easily in the field, since the installation requires no drilling or cutting. An outstanding advantage is the fact that the boom when installed does not interfere with the use of the Trackson McCormick-Deering for drawbar operations.

The W-K-M equipment is made of best quality steel castings throughout. The normal length of the boom is 13½ ft.; extended, its maximum length is 19 ft. The side winch has two drums, each with a capacity for 495 ft. of ½-in. cable. The clutches are of the internal expanding, two-shoe friction type, 13¾ in. in diameter and each 35 in. long. All shocks and strains to the boom and side winch are absorbed by "A" frames provided at each side of the tractor, and the equipment is provided with ball and socket joints throughout to overcome strain through track oscillation.

Mormon boards, special sheaves, stiff legs, pipe hooks for various sizes of pipe and other extra equipment for this unit may also be obtained. Either the Trackson Co., Milwaukee, Wis., or the W-K-M Co., Inc., Houston, Tex., will furnish complete information on request.

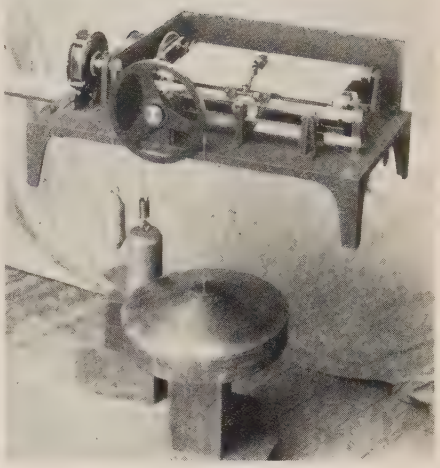
W-K-M Boom and Side Winch Mounted on Model DH Trackson McCormick-Deering

A New Water Level Recorder

Automatic recording devices are rapidly replacing the old method of intermittent observations by a local observer. A new recorder, the Stevens Type A30, combines a float-operated pencil with a continuous roll of graduated paper moved by a weight driven clock. The vital parts are hermetically sealed when in service. This precludes entry of dust and bugs, and largely eliminates errors from expansion and contraction of the paper by humidity changes—an important consideration in moist climates.

The supply roll contains 25 yd. of recorder paper—sufficient for a year's record. The paper has perforations on the margin which mesh with spines on the driving cylinder, thus preventing slippage and lateral displacement. The used paper is taken up on a roller turned by a spiral spring belt from the driving cylinder that keeps the paper gently taut at all times.

Another important feature is the non-slip float line of light non-corrosive metal with tiny brass balls uniformly spaced on it. The balls match recesses in the grooved float pulley. The line with its balls weighs only 6 oz. per 100 ft., yet is strong enough to lift 400 lb.



Stevens Type A30 Recorder

This recorder is regularly equipped to run two months with one setting, but may be equipped for a run of six months or even a year if desired. It is manufactured by Leupold, Volpel & Co., 267 Washington St., Portland, Oregon, and is fully described in their new edition of Bulletin 12 just off the press.

New Motor Housing for Turbine Centrifugal Pump

Ever since the introduction of turbine centrifugal pumps requiring vertical motors, no concerted attempt has apparently been made to design the motor housing as an integral part of the pump, according to H. G. Steele, president of the U. S. Electrical Manufacturing Company. Heretofore, the base of the pump resting upon the concrete at the surface of the ground, was designed by the manufacturer to meet his needs and when the motor was set upon the pump, according to Mr. Steele, sometimes made an awkward assembly that was both ugly and not in keeping with good engineering practice.

U. S. Electrical engineers some time ago began the study of electric motor construction as applied specifically to turbine centrifugal pumps, and finally developed a new motor housing which will be known as the U. S. Turbo Pump Motor. None of the operating units is exposed and the motor is said to be weatherproof. It is designed with the operating parts fully protected and is symmetrical. When set upon the pump base it is said to offer a very pleasing appearance. Literature describing the new pump motor may be obtained by anyone interested in water pumping design from the manufacturers, whose address is 200 E. Slauson Ave., Los Angeles, or from any of the concern's distributing offices.

New Offset Vertical Boom Ditcher

One of the outstanding attractions at the recent convention of the American Gas Association at Atlantic City was a new ditcher, exhibited by the Barber-Greene Co. of Aurora, Ill.—a light ditcher with an offset vertical boom. The offset boom is not offset in any fixed position but may be set at any desired position between the crawlers on which the machine is mounted, and locked there.

This new product of the Barber-Greene Co. is patterned generally after the well known standard vertical boom ditcher, and there are several noteworthy features incorporated in its design.

The vertical boom—a patented Barber-Greene feature—has become familiar to ditching contractors on the larger B-G Model 44-C ditcher.

Another feature of the new utility ditcher is the automatic overload safety sprocket. This affords protection for the machine against overloads, and for pipes and other underground installations against breakage which would prove expensive to the contractor. When an obstruction is encountered, the sprocket slips, stopping the bucket line, catches every half revolution, then slips again. This action will continue without harm to the machine until the obstruction has been removed, or the buckets have milled through it.

The boom is raised and lowered by power, and an automatic throw-out makes it impossible to raise the boom too high.

The whole machine is mounted on sturdy crawlers of standard Barber-Greene design by means of a fixed and an oscillating axle. The oscillating axle provides three-point suspension for the machine, which enables it to ride over rough ground and stay on an even keel.

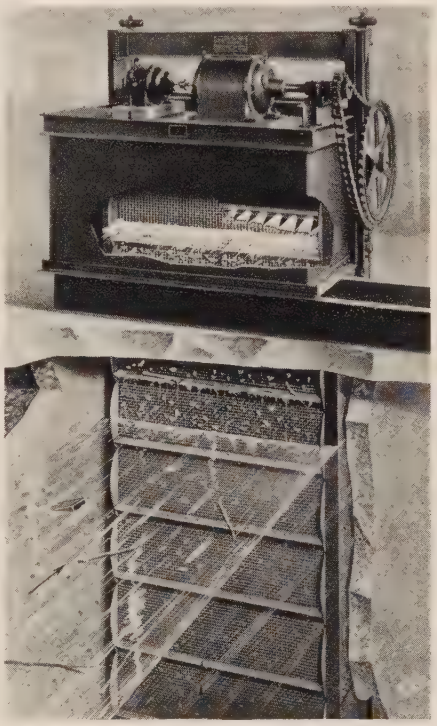
The machine is powered with a Buda 38 hp. gasoline engine and is driven through two especially designed transmissions. It has four road speeds—three forward and one reverse, with a high forward speed of 2⅛ miles per hour—and a great number of digging speeds ranging from 12 in. to 148 in. per minute. There are cutting speeds to suit any soil condition.

The Utility Ditcher cuts a trench from 9 in. to 18 in. wide and from 4 ft. to 5 ft. 6 in. deep. It is light, compact and sturdy.

New Barber-Greene Light Ditcher

New Traveling Water Screen

A new type of traveling water screen embodying many new features has been put on the market by the Chain Belt Co., Milwaukee, Wis. This new screen is an entirely new development at the company and will be built at the company's plant at West Milwaukee. While the general principle of traveling water screens will be maintained the outward appearance of the screen itself has been definitely changed. It will occupy less space than heretofore. Another of its improvements is its accurate sealing and operating features.



New Traveling Water Screen

The two major improvements consist of a new basket design and a new base.

These rectangular baskets hold the screen cloth (which may be of various constructions) and are in turn carried by two strands of Rex Chabelco hardened steel roller chain. The chain operates over head and foot sprockets. As the submerged screen surface becomes matted with the refuse, the screen is revolved. The refuse is then lifted from the intake by the upward travel of the baskets and is automatically removed by means of a powerful spray of water directed through the baskets from their rear, and which washes this refuse into a refuse trough. The spray of water serves to sluice the screen material away for disposal, usually on the down-stream side of the plant.

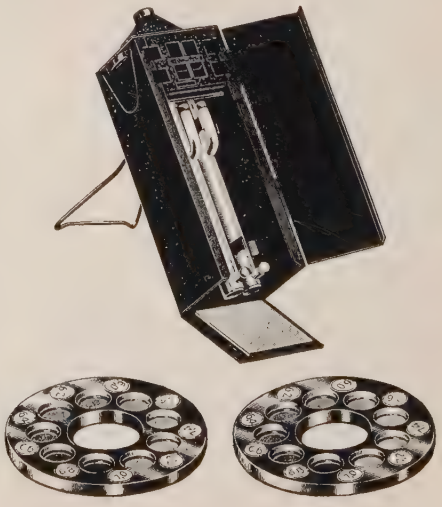
The second major improvement is the radically new design of the foot wheel, which permits the use of the new extended track shoe. This shoe engages the roller at the exact instant that it leaves the wheel. There is no intervening space in which the roller can weave inward, causing openings between the ends of the baskets and the frame of the screen.

Apparatus for Analysis of Water and Sewage

The accurate analysis of water, sewage and industrial waste always has been an important factor for water and sanitary engineers. Until a short time ago the colorimetric tests were hindered by the inconvenience of preparing and rechecking the liquid comparison standards which are said to fade more or less in the course of time. The accompanying illustration shown is water test comparator with permanent color glass standards, made by Hellige-Klitt, Mo., 179 East 87th St., New York, N. Y.

The Hellige comparators for water analysis, hydrogen in control and many other tests have cells or tubes with plane and parallel walls and a prism arrangement which brings the color fields into juxtaposition. It is stated that working with these comparators is very simple and that tests can be made without any special training after a few minutes reading of the directions. No readings from tables or calculations are necessary. The color disc is just revolved until a standard matches with the test solution and the result read directly by a number appearing through an opening in a front of the apparatus.

In addition to the color glass standards for the analysis of water, sewage and industrial wastes, permanent color glass standards are available for hydrogen ion control and many other tests.



Hellige Comparator and Glass Standards

WATER & WORKS SEWERAGE

Design ~ Construction ~ Collection
Treatment ~ Distribution ~ Disposal

May, 1930 — H. P. Gillette Editor — Vol. LXXVII. No. 5

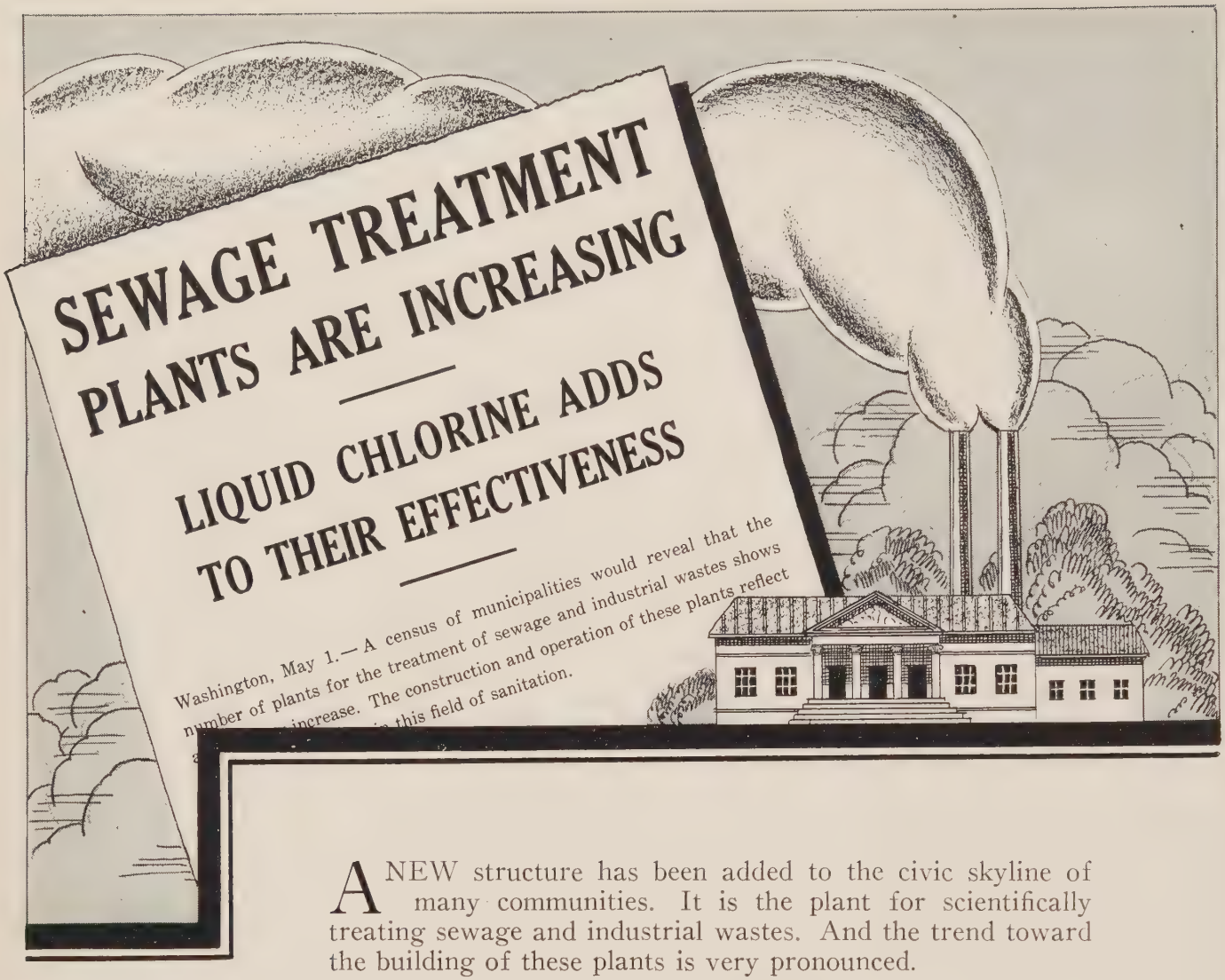
In This Issue:

Recent Trends and Comparative Costs of Sewage Disposal
Francis H. Bulot

A Discussion of Coagulation
John R. Baylis

New Glencoe, Ill., Water Works; Alvord, Burdick & Howson, Chicago, Ill., Engineers; V. A. Matteson, Chicago, Ill., Architect

MEMBER A. B. C.



A NEW structure has been added to the civic skyline of many communities. It is the plant for scientifically treating sewage and industrial wastes. And the trend toward the building of these plants is very pronounced.

It is significant of the general usefulness of Liquid Chlorine in sanitary operations that this chemical destructive of bacilli is employed in sewage treatment with conclusive results.

The importance of sewage treatment to engineers, municipal authorities and others has led E B G to gather valuable information and data on the subject. Your copy will be gladly sent upon request.

Look for the RED Cylinder

YOUR WATER AND SEWAGE
DESERVE THE BEST TREATMENT

Electro Bleaching Gas Co.

PIONEER MANUFACTURERS of LIQUID CHLORINE

Plant: NIAGARA FALLS, N.Y.

Main office 9 East 41st Street New York

E B G

Liquid Chlorine

Water Works and Sewerage

H. P. GILLETTE, Editor

Vol. LXIX MAY, 1930 No. 5

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LIME for Water Purification

Missouri River Water Treatment Plant, St. Louis, Mo., designed by E. E. Easterday and built by the Missouri Engineering and Contracting Co., during administration of Water Commissioner L. A. Day . . . . Great quantities of lime are used in the sedimentation basins, equipped with four Dorr Clarifiers which solve the acute problem of excessive turbidity.

THERE is no question of the value of lime for water purification and softening. Over 145,000 tons of lime used in 1928 is definite proof of the important part played by lime in water treatment plants.

One of the important uses of lime is to effect clarification of turbid water. Prior to the use of lime, turbid water could not be successfully disinfected because of the difficulty in destroying the bacteria imbedded in the suspended matter.

However, during the last twenty-five years lime, used with iron sulphate, alum and other coagulants, has eliminated turbidity, bacteria, color, iron, organic matter and objectionable gases and greatly decreased costs of filtration in cases where the water is to be filtered before being pumped to consumers.

The treatment of water with lime produces a variety of benefits. Not only does lime kill bacteria and soften water, but it also increases the efficiency of sedimentation through effecting better coagulation. Lime neutralizes the organic acids and carbon dioxide where present and reduces danger of corrosion.

Add to its inherent values the fact that lime is economical and available in most every locality, and the reason for its great consumption in water treatment is apparent.

May we send our latest booklet on the uses and value of lime for water treatment? Write for it today.

NATIONAL LIME ASSOCIATION

An organization of leading lime manufacturers formed to encourage a better appreciation of the economic value of lime in all its uses.

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Please mention WATER WORKS AND SEWERAGE—it helps.

Water Works and Sewerage

Vol. LXXVII MAY, 1930 No. 5

Driving Sewer Tunnels Through Quicksand Under Air

Designer Took Advantage of Stiffest Material Located by Borings

By VICTOR J. BROWN
Associate Editor, Water Works and Sewerage

View of Airlock Toward Tunnel

QUICKSAND, when unexpectedly encountered, has caused the failure of many competent contractors. It has spelled the difference between profit and loss on many minor jobs. When properly handled it is as easy to remove as earth. If its presence is known before a job is started and the particular piece of construction work designed with the full knowledge of the expanse and limits of this treacherous material, then not only is greater protection afforded the contractor but a more economical piece of construction results.

In sewer and tunnel work as well as in footings for engineering structures water-bearing silt, fine sand and mucky soil are often encountered. Especially is this true in the flood plain areas of our great rivers. Consequently, when Consoer, Older and Quinlan, Consulting Engineers of Chicago, took charge of the proposed relief sewer problem at Owensboro, Kentucky, on the Ohio River, one of their first field investigations was a complete system of borings a few feet outside the area of the proposed sewer lines. Accompanying this article is the profile of part of Locust St., of the central system, on which borings are clearly shown. Reference to the profile shows the depth at which the lines were placed. The engineers knew that if the lines were laid such that open type construction would be employed, that it would be considerably more expensive than to lay the lines deeper and use tunnel construction. The quicksand nature of the soil and the fact that the lines passed under the built up section of the town are the causes of this decision. Consequently, they decided to get as good a roof as possible for tunnel work and yet not be forced to go too deep. Fortunately they were able to accomplish their design and use the stiffest clay encountered within their possible working depths.

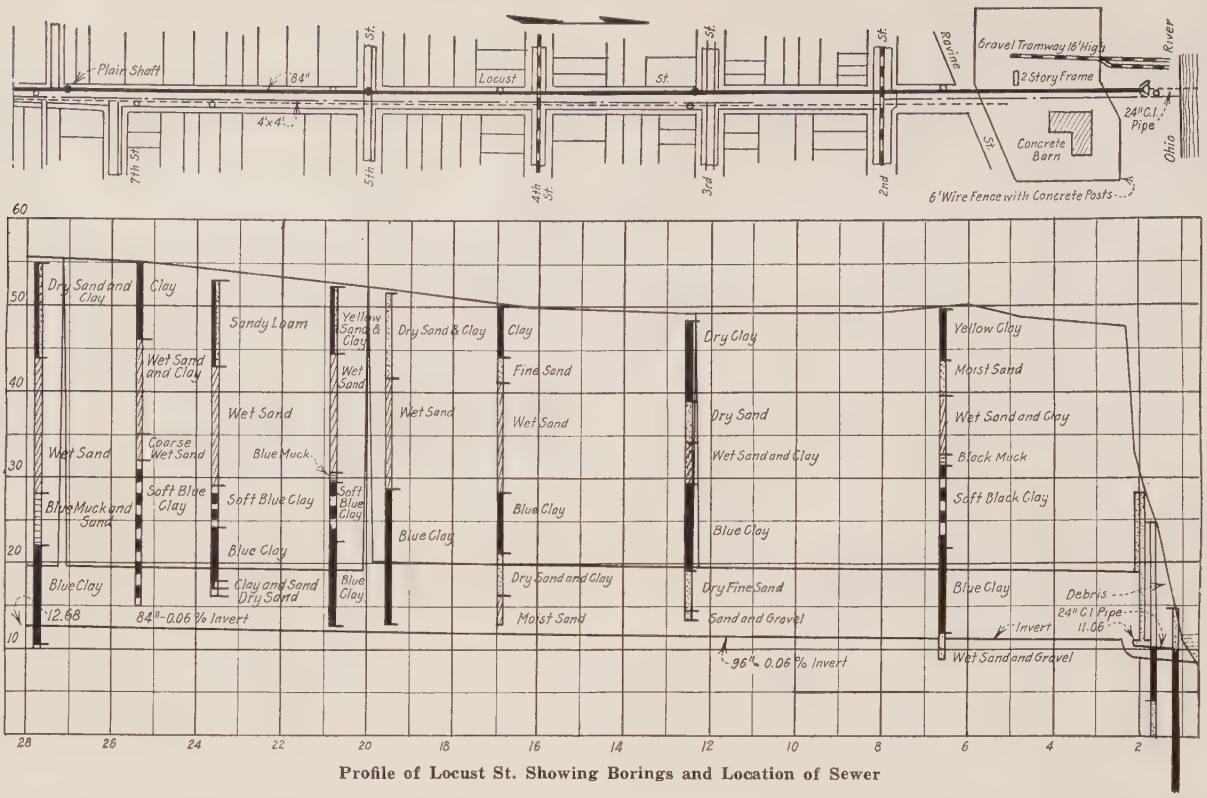
Mining Operations.—The clay stratum underlying the ever present 15 to 20 ft. of sand, silt and water is of a rather strange character. When kept dry or when the water above it can be successfully held back it remains firm and unyielding and mining operations can be continued without resorting to heavy timbering. To keep it this way, the contractor has had to work in 12 to 16 lb. of air on the average. The work is divided among three shifts, working for the full 24 hours as follows:

The day shift starts at 6:00 A. M. When working on a 96-in. section, the usual length of drive for this shift has been 14 ft.; but when working in smaller sections, 84, 78 and 72 in., respectively, the crew is expected to complete the mining on a 16-ft. drive. This is lengthened for the 66, 60 and 48 in. sizes. By 3:00 P. M. the mining crew should be finished and the concreting crew comes on. This crew works until 9:00 P. M. and completes the concrete lining of the previous shift's mining. Then a combination

The Concrete Crew Poses

shift comes on and finishes by 5:00 A. M. This latter crew mines and concretes its own drive. This, arrangement leaves one hour, between 5:00 A. M. and 6:00 A. M. during which time repairs may be made, track fixed or unexpected jobs finished.

The mining operation, in practically all cases, is accomplished in three separate and distinct steps, the first of which may be subdivided into two. In the top half of the section, that above the spring line, a 30-in. width is mined out for one-half the drive required of the shift. From three to five roof boards, 2 in. x 12 in. hardwood stock, are then placed. The previous day's concrete work supports one end of these boards while the end at the face in this part of step number one is supported by face boards which are also of hardwood stock about 10 in. wide.

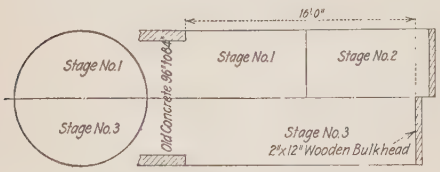


Profile of Locust St. Showing Borings and Location of Sewer

The second part of step number one consists of widening the entry each way from the center until the entire upper half, that above the spring line, is removed. Then a 6-in. steel channel, semi-circular ring, made up of two quarter circular rings bolted together at the center is placed at the face. The ends of the steel ring rest upon boards acting as spread footings. The center is supported under the bolts at the face by an 8 in. x 8 ft. timber surmounted by a short shoring jack.

Step number two is a repetition of step number one extending the top half of the section another 8-ft. drive. In this case, however, the face boards or wooden bulkhead as it may be called is left as a support at one end instead of placing a ring.

Step number three consists of removing the entire bottom half of the section. Ordinarily no timbering is used on the bottom half. Air spades are used exclusively in digging operations and the contractor endeavors to employ short young men for this work. The center support which was placed in the first part of step number one is mined out in this step but is replaced by a longer timber. The screw shoring jack is on the top of the timber while the butt rests upon a 12 in. x 12 in. precast concrete block, the top surface of which is laid at invert grade. The block rests upon a board spread footing. A second jack made of 2-in. double strength pipe is then placed crosswise to stop each foot of the steel ring from collapsing. This is done to keep the ring in place when the bottom is mined out. Just enough of the bottom is left immediately beneath the ring to give it some vertical support until the last minute when it is removed before the concrete is placed.



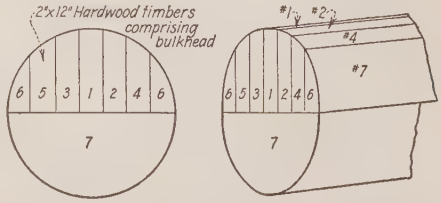
Ordinary Excavation Procedure

Ordinarily the work is carried out in 12 to 16 lb. of compressed air. In a few instances when the amount of protection afforded by the clay roof had fallen away to a depth of 2 ft. or under it was necessary to use 20 to 22 lb. of air. At such times the excavation proceeded at a much slower rate, great care being taken to insure sufficient timbering to hold up the roof. The drives were shortened to 10 ft. or less and 3 in. x 8 ft. hardwood timbers used. The mining operations, however, followed the same sequence except that the only material excavated was that necessary to place one roof board and bulkhead board at a time.

Bulkhead.—The face boards or bulkhead used consists of a series of 2 in. x 12 in. hard wood boards placed vertically in the face and cut to conform in size and shape with the section under construction. At the end of each drive they are placed, a board at a time, in place vertically in the face. For the day shift, it is necessary to place a ring when the first drive is completed and then remove the face boards so as to proceed. When the mining crew finishes their day's work the bulkhead is in place on a short bench as shown by the accompanying diagrams.

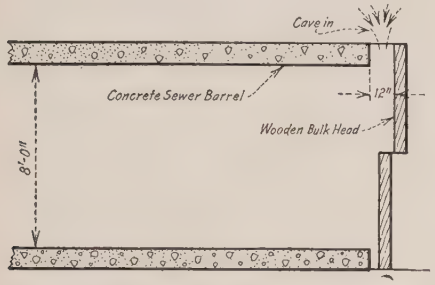
Mining Through Buried Dump.—A rather ingenious method of protecting the roof and retaining the compressed air was used by the contractor to enable him to mine a section of some 60 ft. in length, through a subsoil, a condition not ordinarily encountered. The alignment of the 96-in. trunk sewer on Locust St. necessitated building the sewer through an old ravine, that had been used years before as a city disposal yard, and had been filled up with ashes, cinders, sawdust, and every imaginable sort of debris. This ravine or draw was located some 200 ft. from the river, and in its natural state had formed a drain for the surrounding territory, emptying into the river some 400 ft. above the proposed discharge point of the 96-in. sewer. In times of ordinary high water, the fill in the ravine being porous and in an unsettled condition becomes saturated with water.

When this point was reached with the mining and concreting operation the air pressure dropped from 10 lb. to 3 lb., all of it escaped through the filled up ravine; water began pouring into the tunnel in no small quantities. The contractor immediately built a 2-ring brick bulkhead. on the end of the concrete sewer tunnel already completed,



Method of Starting Entry and Widening

and drilled a 2½-in. hole through the roof some 14 ft. back from the face. Through this hole approximately 1,200 bags of cement grout was pumped, so much, in fact, that the grout forced its way upward some 90 ft. through the way upward some 40 ft. through the old cinder fill to the surface of the ground. The air pressure was then



Conditions Under Which Cave-in Occurred

brought back to approximately 7 lb., the broken bulkhead removed, and mining operations resumed. It was, of course, necessary to break through the grout that had been forced ahead of the tunnel as well as above it but the bad roof was effectively sealed and capped. It was necessary to repeat this operation once more, before natural ground was reached. However, the second time only about 500 bags of cement was used for grouting.

Shaft Construction.—Because of the fluid consistency of the subsoil the contractor found it necessary to drive a box shaped steel sheet pile cofferdam down to the clay stratum. Open excavation continued down for about 20 ft. at which point vertical air locks are constructed. The air locks are made an integral part of the shaft. This shaft later constitutes the manhole. The air locks are knocked out and the side walls smoothed up to complete the manhole.

A peculiar part of the construction of the walls of the shaft-manhole is the fact that the timber bracing used to hold the sheet pile load is concreted in place. This timber bracing consists of 10 in. x 10 in. timbers around the inside of the cofferdam spaced about 5 ft. apart vertically. Corner braces are placed to help strengthen the 10 in. x 10 in. walls. Over the timber there is about 6 in. of concrete making the shaft-manhole walls at least 16 in. thick for the most part.

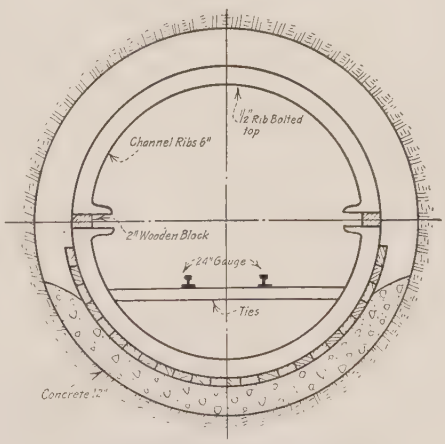
After the vertical locks are constructed excavation continues downward to the flow line. Timber bracing is placed just as before and the walls concreted up to meet the first concrete poured, except for the outlets where headings run out from the bottom of the shaft.

In the mean time, grout is pumped down through pipes to the junction of the clay stratum with the outside of the sheet piling. The cofferdam is sealed on all four sides this way to prevent loss of pressure when the headings are started. After about 50 ft. is opened each way from the shaft, the horizontal locks are built in place.

Concreting.—At 3:00 P. M. after the miners have braced up, the concrete crew goes to work with short handled shovels. A 1:2½:4 concrete in small cars is brought through the lock and dumped out onto the floor as shown in an accompanying picture. Full circular steel rings were placed on line and boards inserted one at a time to hold the concrete until it rose to a height overhead where a space about 24 in. wide was left through which the concrete was shoveled.

The edges of the boards are beveled to fit close and are all laid in the bottom clear up to the spring line to start with. The accompanying sketch gives an idea of the nature of the channel semicircular steel rings and shows how the boards are placed. It will be noted that a 2-in. wooden block is placed between the two halves so that the forms may be wrecked easily after the concrete has set. The top is closed by inserting steel plates progressively, each about 24 in. wide and bent to shape, and shoveling concrete through the slot and over the plates. After concrete has been placed, ties are laid between the steel ribs and rails extended to the face of the heading. A floor is also laid on the ties.

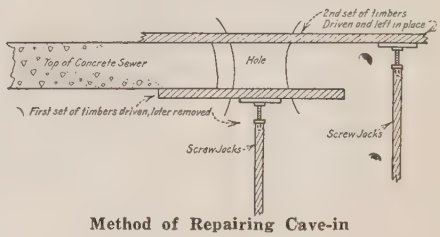
When forms are wrecked the finisher puts on a plaster coat about ¼ in. thick and brushes it. He then puts on two more brush coats after that with a 1:1 mortar. This brush coat is the final finish. In the bottom quarter below the spring line, i. e., over the invert, the concrete is left about 1 in. low when the lagging is placed. To bring the invert to grade a batch of 1:2 mortar is placed in this quarter arc. This gives a hard, smooth invert.



Arrangement of Concrete Forms

At the end of a heading a brick bulkhead is installed until the heading from the other direction meets it. After all concreting is done, clean up of track and floor follows before the bulkhead is knocked out between the new and the old work. Air is then left off to test for leaks. Any that appear are calked with oakum and lead wool. Then the brick bulkhead is knocked out and the barrel finished off.

Handling a Cave In.—A small but rather costly cave in occurred at Eighth and Hathaway Sts. during the construction of the Eastern trunk line. The sewer in question was of 78-in. interval diameter and had been driven some 700 ft. from the shaft. Approximately 15 lb. of air pressure was being used.



Method of Repairing Cave-in

A little difficulty was being experienced in the north heading of the shaft and work was temporarily suspended in the heading in question, while practically all the air was turned into the north heading, the valves in the south being throttled. A full wooden bulkhead had been left in the face of the south heading, and the concrete had been carried to within 1 ft. of this bulkhead, leaving the roof unprotected except for three 2 in. x 12 in. planks, spaced some 4 in. apart, extending from the top of the concrete to the wooden bulkhead. The compressed air in the tunnel had been cut down to approximately 3 lb. and had remained in this condition for about 36 hours when the cave in occurred. The top gave way in the 1 ft. of unprotected roof, and filled about 40 ft. of sewer with sand, clay and some water. A hole, approximately 7 ft. square and some 4 ft. deep, appeared in the street above. The hole in the street was immediately filled with clay, capped with a concrete mat and the air turned back to its original 15 lb. The sewer was then cleaned out up to the original end of the concrete. Poling boards were then driven ahead even with the top inside roof of the sewer and held in place with a miner's ring and screw jacks. The ground or earth underneath this protection was then excavated and taken out. A second set of boards were driven from the face back to catch the top of the existing concrete. These timbers were 3 in. x 8 in. hardwood and were made to fit as close together as possible. The original set of timbers put in at first were then removed, and the concrete hurriedly put in, thus shielding and capping the hole. As an extra precaution a grout pipe was inserted in the section afterward and about 100 bags of cement grout was forced into the hole and around the sewer barrel to guard against future leakage.

An investigation of the borings at this point showed about 5 ft. of soft clay on the roof of the tunnel, topped with 20 ft. of sand and water. With the air reduced to a minimum the water

seeped through the clay, weakening it until it finally gave way.

Organization of Crews.—The excavating crew was organized as follows:

2 miners
3 muckers } One heading
1 locktender }
1 pit man
1 hoist man on top
1 box dumpman
1 foreman at shaft

Two headings were worked out of each shaft, hence a double heading crew. Electricity is used throughout. The boxes hoisted through the shaft are dumped by one man on top by simply sliding a beveled platform on rails under the box then lowering the box. The box dumps into a hopper out of which trucks haul the material away to convenient dumps. A heading crew averages about 35 cu. yd. of material per shift.

The concrete crew is organized as follows:

1 pusher }
4 shovelers } One heading
1 lock tender }
1 mixer operator
1 hoist operator
1 foreman

Duties of Inspectors on Sewers.—Inspectors will carefully note the following: 1. Check position of model, both as regards to grade and center-line of sewer. Be sure that it is suitably blocked, with at least one good block directly underneath it. 2. We call for a 12-in. thickness of concrete on all sewers 84 in. and over, and 10-in. thickness on all sewers 78 in. and under, built in tunnel. Be sure that the proper amount of dirt has been excavated from the bottom and sides to get this thickness. 3. We use a 1:2½:4 mix of concrete, or 1 bag of cement, 2½ bags of sand and 4 bags of gravel, which are the exact contents of each wheelbarrow for the two-bag mix used on this job. 4. A minimum of one minute is allowed for time of mixing of each batch. 5. After the bottom has been poured up to the spring line, and before the lagging is put in position, place a 1:2 mortar coat on the bottom quarter of the sewer barrel. 6. Be sure all lagging and key plates have been properly oiled before being used. 7. When the rings are installed, be sure that they line up, in a straight line from the old work to the model. 8. Check the top half and roof for sufficient thickness of concrete. 9. The first two batches of concrete after bottom lagging and ring installation should be quite wet. Use one batch on each side. 10. Then, remove side boards and insist on sufficient pounding of lagging at the lower quarter points to insure a good face on finished concrete. 11. Thereafter insist on the hitting of the lagging with hammers, after every three board installation; concrete should also be well spaded during this process. 12. Keep the concrete mix quite wet and plastic throughout the pouring of the section from the spring line to the placing of the key plates. 13. Before the first key plate is installed, insist on a repounding of all lagging previously placed. 14. Stiffen up mix of concrete during keying-up process. 15. After the first two or three shovels of concrete have been deposited on the plate, tap the bottom of them lightly with a hammer. 16. When keying up, be sure all voids are filled up from the plate to the roof; this can be accomplished by shoving the concrete back against the roof with a 2x4-in. timber.

Records to Be Kept.—Keep accurate records of events as stipulated below: Keep accurate count of actual number of sacks of cement used during operation. 2. Record length of concrete section poured, along with date and the heading in which the operation took place. 3. Record any difficulty or peculiarity encountered during the process of the work—anything which in your opinion the Engineer should be advised of.

Those Responsible.—The work is being done by Thos. D. Nolan, Contractor, Detroit, Mich., under the supervision of Consoer, Older and Quinlan, Consulting Engineers, Chicago, Ill., for the city of Owensboro, Kentucky, on a bond issue. The engineers' estimate on the job was $1,130,000 for construction work. Nolan was the low bidder at $1,098,000, all other bids exceeded the estimate.

Mr. George Consoer is handling the job out of the Chicago office for the engineering firm; Mr. Joseph A. Schudt is their construction engineer. Mr. Carl Ketchum is superintendent and engineer for the contractor. Over $300,000 worth of work has been completed to date without a single serious accident.

Difference Between Merger and Consolidation

In the recent consolidation proceedings of the Eastport Water Company before the Maine Commission, an interesting discussion of the difference in meaning, if any, of the words "merger" and "consolidation" was given. The following discussion by the commission was taken from Public Utilities Fortnightly:

"The process by which it is sought to combine these several corporations into one has been generally referred to as 'consolidation' proceedings; the evidence shows that the stockholders voted to 'merge and consolidate with Maine State Water and Electric Companies'; counsel on both sides have frequently used the terms 'merge' and 'merger' throughout their discussion of the case, and our statute uses the expression 'merge or consolidate.'

"The consolidation of corporations strictly speaking contemplates and results in a dissolution of the constituent companies and the formation of a new corporation. (Scheidel Coil Co. v. Rose, 242 Ill. 484, 90 N.E221.)

"A merger is generally said to exist where one of the constituent companies remains in being, absorbing or merging in itself all the other constituent corporations. Such a merger, however, is often properly termed a consolidation. These proceedings do not seem to us to fall within the strict rule either of merger or consolidation, although partaking to some extent of the essential elements of both. (Re Bangor R. & Electric Co. P. U. R. 1925 E 705.)

"Courts have sometimes held, however, that the results of consolidation are somewhat dependent upon the wording of the statute, and that as a general rule consolidation dissolves the original corporation involved and creates a new one, but if the legislature simply authorizes consolidation the general rule applies." (Re Eastport Water Co. U—1046 et al.)

Florida Section, A.W.W.A., Holds Annual Meeting

The fourth annual meeting of the Florida section, American Water Works Association, was held in Gainesville, Fla., on April 10 and 11. It was preceded by the first short course in water and sewage treatment offered by the General Extension Division of the University of Florida, in conjunction with the Florida section, American Water Works Association, and the Florida State Board of Health, on April 8 and 9. Enrollment for the short course considerably exceeded the expectations of those in charge, 69 having registered during the two days in which it was given. Conforming with the request of the association, the short course will be made an annual affair, and the time will be extended to four or five days, thus permitting a more thorough treatment of the subjects discussed.

The registration for the fourth annual meeting was the largest in the history of the section, some 125 being in attendance. During the two-day session 19 papers were presented and discussed.

West Palm Beach, Fla., was selected as the meeting place for 1931. Officers elected were as follows: A. P. Black, professor of chemistry, University of Florida, Gainesville, Fla., chairman; F. W. Lane, St. Petersburg, Fla., vice-chairman; E. L. Filby, State Board of Health, Jacksonville, Fla., secretary-treasurer (re-elected). Director for 1932 is J. R. Hoy, Jacksonville, Fla. Directors for 1933 are J. R. Tanner, West Palm Beach, Fla., and T. W. Grant, Tampa, Fla. Representative to the National Council, A.W.W.A. is A. P. Michaels, Orlando, Fla.

Retiring officers for the year are: Ralph W. Reynolds, West Palm Beach, Fla., chairman; Charles H. Eastwood, Jacksonville, Fla., vice-chairman; E. L. Filby, Jacksonville, Fla., secretary-treasurer (re-elected).

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Filtration Engineer, Bureau of Engineering, Chicago, Ill.

Coagulation

So much has appeared on coagulation in the technical literature within the past ten years that a discussion of this subject at the present time may seem out of place. This is an attempt to explain more clearly certain phases of coagulation. It is limited largely to the structure of gelatinous precipitates, their composition and the way in which they remove suspended matter from water. By a more thorough understanding of what takes place when water is coagulated with the aluminum or iron compounds it is believed that these materials may be used to better advantage in some filtration plants.

Coagulation Followed by Filtration Through Rapid Sand Filter Beds Used Most Extensively.—Coagulation of turbid waters followed by filtration through rapid sand filters has almost become the universal practice in the United States. The number of slow sand filtration plants constructed within the past 15 years is very few compared with the number of rapid sand plants that use a coagulant prior to filtration. In fact some of the slow sand plants use a coagulant when the water is fairly turbid. Coagulation of the water followed by a period of mixing, settling and then filtration through coarse sand beds at a high rate has demonstrated its superiority over filtration through fine sand at slow rates without chemical treatment so conclusively that it is believed very few slow sand plants will be constructed in the future.

Structure of Gelatinous Precipitates Difficult to Determine.—The main function of the chemical treatment in most filtration plants is to produce a coagulation that will entrap the suspended particles such as mud, bacteria and microörganisms, and bring them together into fairly large masses of the coagulant with this matter entrapped. The nature of jellies and gelatinous precipitates has been the subject of much controversy among chemists and there is not general agreement at the present time as to the makeup of such precipitates. To attempt to give a discussion on coagulation without making it too technical for engineers, and filter operators other than chemists, is a very difficult task. The fact that we are dealing with fibers or particles in gelatinous precipitates so small that the most powerful microscope will not reveal their structural formation makes an explanation still more difficult and leaves room for doubt with any explanation that may be given. If one were standing on a mountainside looking at a forest 10 miles away without field glasses of any kind he would be in about the same position with regard to determining the size and shape of the limbs on the trees as we are in trying to determine the structural formation of gelatinous precipitates of hydrous aluminum oxide with the microscope. The writer prefers to use the term "hydrous aluminum oxide" as used by Weiser to express the precipitate formed from aluminum sulfate instead of "aluminum hydroxide" which is used so commonly in the literature on water treatment.

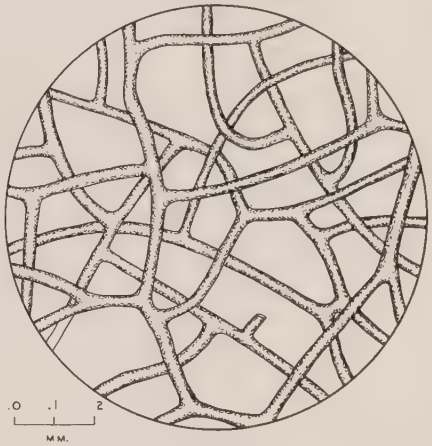


Fig. 1—Camera Lucida Drawing of Sponge

That there is an enormous increase in the volume of the hydrous aluminum oxide precipitate over an equal volume of commercial aluminum sulfate (this contains about 17 per cent of aluminum oxide) is well known. It is also known that the precipitate forms with sufficient adhering or binding force for the particles of flocculated matter to form large enough to be seen without magnification. Anything that holds together must have some binding force, even though very little is required to hold it together in water. The difficulty in trying to form some idea as to how strongly such precipitates are held together is so great that not much information is available. The engineer can measure the strength of structural materials with considerable accuracy, but when it comes to measuring the strength of fibers sub-microscopic in size the task is not so simple.

Probable Makeup of Gelatinous Precipitates.—The belief is now fairly general that gelatinous precipitates are composed of a network of extremely finely divided particles which have coalesced to form flexible and irregular-shaped filaments or chains. These filaments absorb water very strongly and consequently are very hydrous. There probably is nothing to which we may accurately compare the makeup of a gelatinous mass. Some have attempted to compare it with a brush-heap, yet it is evident that this cannot be a true comparison, for the limbs of trees are more regular in shape than the fibers of most gelatinous masses are believed to be. More frequently the structural formation is said to be sponge-like. To give some idea of what is meant by this term, a camera lucida drawing of a sponge is shown in Fig. 1. It also should be evident that the fibers of the sponge are too regular in shape to give a true comparison.

The writer's conception of the makeup of gelatinous precipitates of hydrous aluminum oxide and hydrous ferric oxide is illustrated by Fig. 2. While this is a camera lucida drawing of fibers of iron rust on the inside of tubercles where iron has been corroding, and the fibers are perhaps thousands of times larger than those of a gelatinous precipitate, they form an irregular meshwork that probably represents a gelatinous precipitate if the fibers could be magnified to this size. It is not believed that the magnification produced by the most powerful microscope is near what would be necessary for detecting the fibers that constitute the makeup of many gelatinous precipitates; therefore, our conception of such precipitates lacks definite proof. The best we can do is to observe the formation of certain precipitates that form fibers or particles large enough to be

seen with the microscope and to assume that the gelatinous precipitates are formed in the same general manner. Barratt[1] claims to have observed a non-crystalline fibrillary structure which formed an enmeshing network in fibrin jellies. In fact, several authors claim to have observed the fibrous formation in certain jellies. The writer has not observed gelatinous precipitates in which the structure of the precipitate could be detected, but has observed conditions that may give some clue to their formation.

Formation of Calcium Carbonate Precipitate on the Surface of Limewater May Be Similar to the Formation of Gelatinous Precipitates.—The formation of a precipitate of calcium carbonate at the water-air surface of a strong solution of calcium hydroxide may give some indication of what takes place in the formation of gelatinous precipitates. Within 5 to 10 seconds after exposure to the air a large number of calcium carbonate spherules are formed, which are in rapid brownian movement. These spherules increase in size quite rapidly, but before they are more than 2 to 3 micra (one micra is 0.001 mm.) in diameter they begin to adhere into chains somewhat like a string of beads. The attractive force of the chain for the unattached spherules appears to be very much greater at the ends of the chain than along the sides, especially after the chains have lengthened 5 or 6 spherules. A few spherules may attach themselves along the sides after the ends of the chains have joined together over the surface, but the force along the sides certainly is not nearly so great as at the ends. If this were not the case the spherules would just clump together and form a mass somewhat like that of moist sand thrown from a shovel so as to make it as loosely compact as possible. For precipitates that form a volume greatly in excess of the actual solid that makes up the precipitate, it is necessary when two spherules unite that they have a much greater attractive force for other

[1] Biochem. J., 14: 189, 1920.

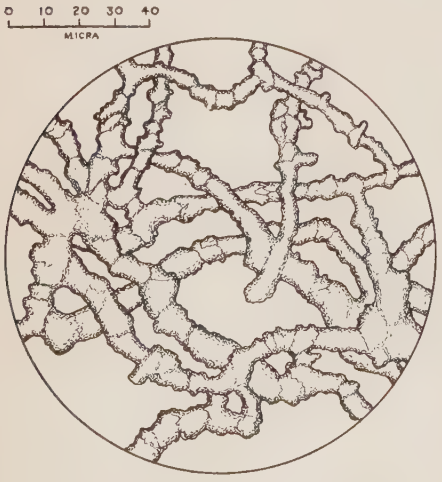


Fig. 2—Fibrous Iron Rust from Tubercle

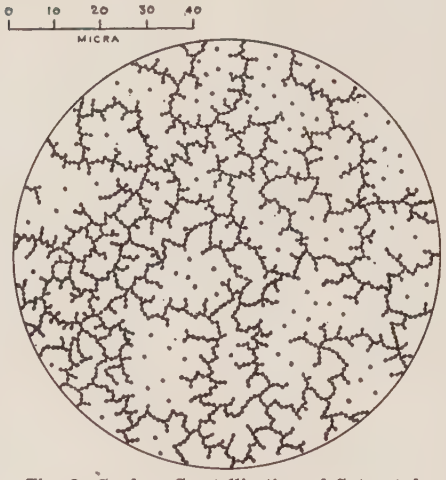


Fig. 3—Surface Crystallization of Saturated Solution of Limewater Exposed to the Air One Minute

spherules along the line of the chain than along the sides.

The drawing in Fig. 3 represents the surface of a saturated solution of limewater exposed to the air about one minute. It is noted that the chains have joined into a network over the surface and there are only a few free-floating spherules. Most of these became attached within the next two or three minutes. The drawing is only partially camera lucida, for it is evident that such a drawing as shown could not be made from something that is changing rapidly. The strength of the limewater solution has considerable influence on the size of openings in the meshwork. A saturated solution will form a meshwork with openings very much smaller than a solution only one-tenth saturated. After the formation of the meshwork of chains of spherules, the solution continues to absorb carbon dioxide from the air and this keeps the solution supersaturated with calcium carbonate for some time. This builds up the fibers or chains much larger in diameter than they would be if no additional carbon dioxide gained access to the solution and they look more like smooth fibers than chains of spherules. This is shown by Fig. 4. Occasionally conditions were produced with solutions less than saturated in which the spherules did not coalesce. The reason for this was not determined.

The first solidification of calcium carbonate at the water-air surface very likely is crystalline, but it is not a stable crystallization, for after the strength of the limewater solution has been reduced quite materially at the surface by adsorbing carbon dioxide from the air, typical calcite crystals begin to form. These crystals increase in size as the first solidification near the crystals goes back into solution, indicating that the calcite crystals are a more stable form of calcium carbonate. This is illustrated in Fig. 4, the drawing having been made about 30 minutes after exposure to the air. A gelatinous precipitate of calcium carbonate may be formed within the mass of the solution under certain conditions with high concentrations and when an enormous supersaturation is produced very rapidly, such as the mixture of two strong solutions, one containing the calcium and the other the carbonate. This also is not a stable precipitate and changes to a more crystalline form, perhaps in the same manner as the precipitate at the surface of limewater. The same phenomenon has been observed with other precipitates. Endres[2] describes and illustrates changes in the crystallization of sulfur in rubber, showing rhombic crystals growing at the expense of the unstable dendritic form. As to whether such things happen with the precipitates of hydrous aluminum oxide and hydrous ferric oxide produced in water treatment, there is considerable doubt, although there are a few references in the literature to certain precipitates becoming more crystalline on standing.

We have no absolute proof that the hydrous oxides of iron and aluminum form gelatinous precipitates by first forming spherules and then a coalescence of the spherules, though the evidence is fairly conclusive. The fact that the compact precipitates are 20 to 40 times the volume of the actual solids going to make them up, makes it seem impossible that they could form such a porous precipitate in any other manner, except possibly by the formation of needle crystals. Comparison of the calcium carbonate fibers in Fig. 3 and 4 indicates that the nearer the solution is exhausted of its supersaturation before coalescence takes place the weaker will be the fibers. Where there is coalescence with considerable supersaturation it may be possible for the chains to grow larger in diameter the same as the calcium carbonate chains. The reason for giving so much space to the surface solidification of calcium carbonate is because it is something we can see, and the manner in which it takes place is in accordance with the

[2] Colloidal Chemistry, J. Alexander. Vol. 1, pp. 808-13, The Chemical Catalog Co., 1926.

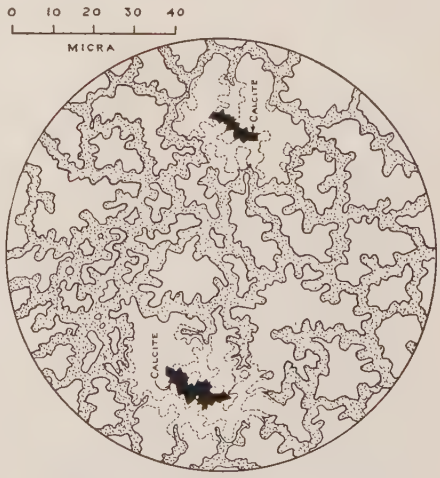


Fig. 4—Surface Crystallization of Limewater After Typical Calcite Crystals Have Begun to Form

theories of the formation of gelatinous precipitates.

Precipitation of Hydrous Aluminum Oxide.—The addition of aluminum sulfate to water containing sufficient alkali or alkaline carbonates produces a gelatinous precipitate commonly called alum floc. The sulfates react with the alkalies in the water and remain in solution except the amount that is adsorbed, and the aluminum forms a hydrous oxide. The hydrous oxide being very insoluble, it forms a percipitate when the pH of the water is between 6.0 and 8.0. In fact, it forms precipitates below and above the figures given, but increasing amounts of aluminum are found in solution as the distance from this range increases in either direction, probably being an acid compound on the acid side and an alkaline aluminate on the alkaline side.

There are still differences of opinion as to whether the gelatinous precipitate is amorphous or crystalline. The evidence seems to be in favor of a crystalline structure, though it probably makes little difference in water treatment as to which it may be. The minute solid particles before they coalesce are in rapid brownian movement and possess a positive charge. The assumption is that the positive charge is due to adsorption of hydrogen ions on the surface of the solid particles. In addition to this surface layer that gives it its electrical charge, the minute particles adsorb or draw close to their surface negative ions which tend to neutralize the charge on the particles. This is referred to by Michaelis[3] as an electric double layer in that there is a positive layer directly on the solid surface and a negative layer surrounding it, but probably not touching the positive layer.

If the solid particles of hydrous aluminum oxide happen to be submerged in water containing no negative ions other than the $(OH)^-$ ions of dissociated water, this, together with the hydrogen ions, would be the extent of their adsorption. Under some conditions this might be sufficient neutralization of the positive charge to allow coalescence to take place, though it probably is not under concentrations used in water treatment. This, however, is immaterial in water treatment, for we never have water in public supplies that does not contain other negative ions. Not only this, but the negative ions of aluminum sulfate or ferrous sulfate alone are sufficient to produce coagulation if fairly large quantities of the coagulant are used.

It is presumed that the ions most highly adsorbed will be the ones adsorbed to the greatest extent, and that bivalent ions will be adsorbed more readily than monovalent ions. There may be $(SO_4)--$, $(Cl)-$, $(HCO_3)-$ and $(OH)^-$ present. In fact, most natural waters contain mixtures of these ions.

[3] The Effect of Ions in Colloidal Systems. Williams & Wilkins Co., 1925.

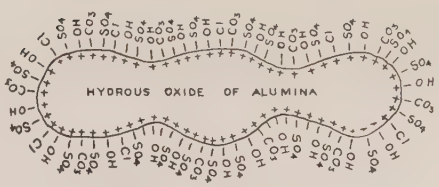


Fig. 5—Adsorption of Negative Ions by Hydrous Oxide of Alumina, Which Produces Coagulation

The sulfate and probably the chloride ions readily neutralize the charge on positive sols (the minute solid particles before they coalesce) of aluminum and iron hydrous oxides and cause coalescence of the particles. The carbonate ions will cause coalescence when the concentration is high, and the hydroxyl ions probably will not at pH values below 7.0. Above pH of 7.0 the tendency to adsorb hydrogen ions drops off as the concentration of $(OH)^-$ ions increases and fewer negative ions are required to neutralize the charge. At a pH of 9.0 very few hydrogen ions are adsorbed by the minute particles and practically no sulfate or other negative ions except possibly the hydroxyl ions are adsorbed. The number of negative ions adsorbed will depend somewhat on the concentration of negative ions in the water. When 17 p.p.m. (one grain per gallon) of aluminum sulfate are used to coagulate water very few sulfate ions are adsorbed at a pH of 7.0, whereas an appreciable amount will be adsorbed if 100 p.p.m. or more are used.

A small particle of hydrous aluminum oxide, supposed to represent the coalescence of three spherules of the sol, is shown in Fig. 5. The actual size of the particle is so small that it cannot be seen with the microscope. The positive charge at the surface is shown just inside the particle, though it is thought to be due to a layer of hydrogen ions on the outside. The writer has never fully understood why a layer of adsorbed hydrogen ions is necessary to give the particle a positive charge; nevertheless, this is what is assumed by leading colloidal chemists to give it such a charge. The negative layer is distinctly on the outside of the particles and while very close to the positive layer it may not actually touch it. Some are of the opinion that adsorbed layers are only one ion or molecule in thickness, others believe it may be thicker, and still others account for such mixtures of ions with a solid as being in solid solution.

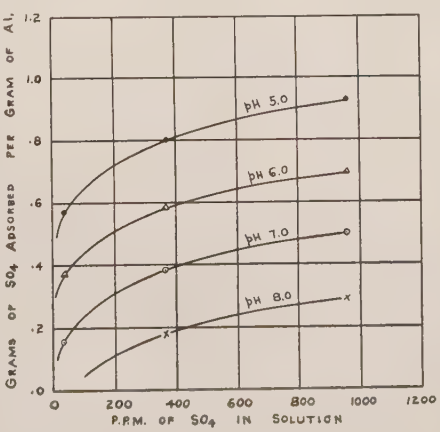


Fig. 6—Effect of pH of SO_4 Adsorbed by Hydrous Aluminum Oxide

The drawing in Fig. 5 shows SO_4, Cl, CO_3 and OH ions forming a negative layer just outside the positive layer. The relative proportion of these ions in the layer will depend on their concentration in the water and their tendency to be adsorbed. That ions other than the SO_4 ions aid in forming a precipitate seems evident. It is possible to get a very good precipitate in some surface waters with only 5 p.p.m. of aluminum sulfate, whereas by taking distilled water and adding 20 p.p.m. of aluminum sulfate and enough sodium or calcium hydroxide to bring the pH to the optimum point it is difficult to form a precipitate. It seems that the only conclusion we may form is that the other negative ions aid in the formation of the precipitate. This may be why some of the very soft waters are more difficult to coagulate than some of the hard waters.

Negative Ions Precipitated With Hydrous Aluminum Oxide.—In the formation of a gelatinous precipitate when aluminum salts are added to water it seems reasonable to expect the precipitate to contain some of the negative ions of the salt. This is actually what happens in most instances, though it is possible for the precipitate from aluminum sulfate to be practically free from sulfates after washing when the pH is high. Miller[4] probably was the first to investigate the sulfate content of precipitates of hydrous aluminum oxide. He found the sulfate content of the washed precipitate to vary with the pH of the solution in which it was precipitated. Concentrations very much higher than are used in water treatment were used by Miller, and he came to the conclusion that the concentration of sulfates had no effect upon the amount found in the precipitate. He also came to the conclusion that the sulfate was in solid solution instead of being adsorbed by the hydrous oxide. Hopkins[5] made a similar investigation, using more dilute solutions, and came to the same conclusion as Miller—that the sulfates are in solid solution.

It is believed that Miller and Hopkins are mistaken in their assumption of the solid solution, though their conception of a solid solution may not differ materially from the physical or colloidal chemist's conception of adsorption. We can take their data and construct typical adsorption curves by taking into account the effect of hydrogen-ion concentration. The SO_4 adsorbed at a definite hydrogen-ion concentration apparently does vary with the concen-

[4] Public Health Reports, 38: 35, 1995-2004, Aug. 31, 1923.

[5] J. Am. Water Works Assoc., 12, 4, 405-9, December, 1924.

tration of the SO_4 in the solutions, and gives curves that follow the Freundlich adsorption equation very closely. This is shown in Fig. 6. The points for the concentration of slightly less than 1,000 p.p.m. of SO_4 were obtained from Miller's data, and the other points were computed from Hopkins' curves for 5 and 50 grains per gallon of aluminum sulfate. Miller and Hopkins plotted these curves with the pH against the $Al:SO_4$ ratio. To be exact, the sulfate adsorbed should be deducted from the sulfate in solution as shown, for the concentrations in solution are computed from the added sulfates. As the curves are not intended to be exact, this makes little difference.

These curves are given merely to show that they are typical adsorption curves at definite pH values. Hopkins' curve for one grain per gallon would give points out of line from the ones shown, but as only two points for this amount of aluminum sulfate are given, more exact data over a wider pH range probably will show it to be more in line with what should be expected. The reason that Miller got very little additional adsorption of sulfate ions by increasing the concentration four times is that the precipitate had practically reached its maximum adsorption with his lowest concentration. Not only this, but some of the sulfate may have been washed away in the washing process. Taking Freundlich's adsorption equation $A = \alpha C^{\frac{1}{n}}$ and assuming values for the constants, curves can be plotted that fit the ones shown very closely. In the equation, A is the grams of SO_4 adsorbed by one gram of Al in the form of the hydrous oxide, C is the concentration of sulfate in solution in parts per million and α and $\frac{1}{n}$ are constants. If we assume that $n = 5$ and $\alpha = 0.175$ in the curve for pH of 6.0, it will give a curve almost exactly the same as the one shown. Each curve will have different constants. In commenting at length on the work of these authors, especially that of Miller, it is not intended to convey the impression that the work is inaccurate and of no value. Their data are very valuable, and it is merely a difference of opinion as to the interpretation of the data. Buswell[6] and Weiser[7] came to the same conclusions as the writer in regard to the interpretation of Miller's data.

Precipitation of Hydrous Ferric Oxide.—The precipitates formed by adding iron compounds to water are very much like those of the aluminum compounds. Most iron used in water treatment heretofore has been the ferrous sulfate. The first reaction of this compound with the water is to form ferrous hydroxide, which is oxidized to hydrous ferric oxide by the dissolved oxygen of the water. Recently ferric salts have been used to a limited extent in water treatment. Ferrous sulfate may be converted to ferric sulfate and ferric chloride by the addition of chlorine to a solution of ferrous sulfate, or ferric chloride may be used direct.

When ferrous sulfate is used it is necessary to have the water alkaline, with pH above about 8.5, to get fairly quick precipitation of the iron. With ferric salts good results are obtained within the pH range of 5.0 to 10.5. In fact, precipitates are obtained slightly beyond this range on the acid side, and there may be no limit on the alkaline side. Miller[8] also studied the precipitates formed from the iron compounds and came to the conclusion that hydrous ferric oxide was very much like that of hydrous aluminum oxide. When sulfate of iron was used, sulfates were precipitated with the hydrous oxide the same as with the aluminum. The washed precipitate was found to be practically free from sulfate at a pH of 7.7 or above, which is somewhat lower than the pH at which no sulfates are found in the aluminum precipitate. Also there was not as much sulfate adsorbed by the iron as with the aluminum at lower pH values. From this we might conclude that no sulfate is precipitated with or adsorbed by the hydrous ferric oxide when lime is used with the treatment.

There is every indication that the structure of the gelatinous precipitate of hydrous ferric oxide is very much like that of the aluminum precipitate. Very likely the fibrous formation is similar to that shown in Fig. 2, although the fibers are very much smaller. With the precipitate formed in alkaline water, as is the customary practice for ferrous sulfate, not much value is obtained from the iron as an adsorbing agent. Ferric salts give good precipitates at low pH values and adsorption may be made a factor. When ferric chloride is used it seems probable that the monovalent $(Cl)^-$ ion may be replaced by certain negative organic ions, and that it would be more effective than hydrous aluminum oxide for removing certain compounds from water.

Aid of Coagulants in Removing Objectionable Substances From Water.—The uses of coagulants in water treatment are to remove turbidity, color, bacteria and microörganisms—in fact, we might say, all material that keeps the water from being perfectly clear. The removal of turbidity and microörganisms is almost entirely mechanical, but the removal of color may be largely by adsorption, in which case the pH and also the concentration and kind of negative ions will play an important part as to the amount of color that will be adsorbed. Most turbid waters contain very little suspended matter with an electrical charge so high as to obstruct coagulation, and while cataphoresis tests may indicate that the particles are positively or negatively charged, this is of minor consequence. These statements do not apply to color except where the particles of color are large enough to be removed mechanically, nor to certain compounds that may occasionally be present in some waters. Most of the suspended particles that produce turbidity in water are fairly large compared to the minimum size of solid particles that might be produced.

If the gelatinous precipitates of the hydrous oxides of iron and aluminum are somewhat as represented in Fig. 2, and there is every indication that they are, it is easy to see how suspended particles 0.5 micron in diameter or larger are entrapped in the coagulant. In most turbid waters there are very few suspended particles less than one micron in diameter. Should any of the particles possess an electrical charge that favors their being drawn to the precipitate, so much the better; but if they possess a charge the same as that of the coagulant they will be entrapped just the same, so we need not give the matter of electrical charge little concern in most waters. If the negative ions reduce the charge on positive particles of the coagulant so they may coalesce, then they would reduce the charge on any other positively charged particles that happen to be in the water, and while the particles probably will not coalesce they will not repel the coagulant to the extent that the particles cannot be entrapped.

There are a few conditions where the water receives pollution of a certain nature that produces turbidity which is difficult to remove. In these cases the difficulty probably is due more to the number of extremely finely divided particles than to their charge. This is not saying that compounds cannot be added to water that prevent or retard coagulation, but such compounds do not get into our water supplies so frequently as to be of major consequence except in very few cases.

Has Research Work on Coagulation Been of Practical Value?—Very likely the reader is now wondering what difference it makes if the negative ions are adsorbed or if they are in solid solution in the precipitate, or whether the precipitate is amorphous or crystalline. So far as is known it does not make any material difference when precipitates are produced from compounds in solution, but if we were adding hydrous aluminum oxide or hydrous ferric oxide to water instead of aluminum sulfate or ferrous sulfate, it might make some difference in the removal of certain compounds. We know there is no difficulty in nearly all instances in obtaining good precipitates in water treatment where the pH is between 6.0 and 8.0 for aluminum sulfate,

[6] The Chemistry of Water and Sewage Treatment, p. 168, The Chemical Catalog Co., 1928.
[7] The Hydrous Oxides, p. 127, McGraw-Hill Book Co., 1926.
[8] Public Health Reports, 40: 27, 1413-19, July 3, 1925.

8.5 to 10.5 for ferrous sulfate and 5.0 to 10.5 for ferric salts.

The water purification chemist or engineer is more concerned with the quickness with which precipitates form, their strength and their effectiveness in removing certain constituents from water, than the chemical composition of the precipitate. The composition of the precipitate, however, is giving some information of what happens when precipitation takes place, and when understood more thoroughly it may enable us to use certain materials to better advantage. We should not dismiss the chemical characteristics of the precipitates and their structural formation as of little importance just because we cannot at the present time show the relative values of the constituents and the exact manner in which the solid portions are held together.

It may be found that the adsorption of negative ions by the precipitates is without practical significance in most waters, and we know that it is for some waters, for it is just as easy to clarify the Great Lakes water at a pH of 8.0 with a very small amount of aluminum sulfate as it is some of the other waters at a pH of 6.0 Very little or no sulfate is adsorbed at a pH of 8.0, whereas at a pH of 6.0 the curve in Fig. 6 indicates that about 0.3 grams of SO_4 is absorbed per gram of Al in the hydrous oxide when 40 to 50 p.p.m. of aluminum sulfate are used.

If research work on coagulation has not been of practical value to many filtration plants, it has been to those handling water difficult to coagulate. It has shown in some instances that it is advantageous to take the water out of the bounds of what would be considered a satisfactory water to accomplish a certain thing and then to bring it back to a satisfactory water by additional chemical treatment.

Water Problems Discussed at "Question Box"

Problems of interest to water-works officials and engineers were discussed through the medium of a "question box" at the Hamilton, Ont., meeting of the Canadian section of the American Water Works Association. Questions, submitted by members and incorporated in a printed questionnaire, and replies are given below:

1. Who makes repairs to services on private property where water works have installed service in the first instance? In reply to this question, T. Hodkinson, of London, Ont., said that in his city the utilities commission lays the service 20 ft. inside the property line and keeps it in repair for one year. After that the property owner has to undertake repairs or pay the utility commission to do the work. M. Pequegnat, of Kitchener, Ont., said that the owner was notified of leaks and asked to have repairs made. In Shawinigan Falls the repairs are made and paid for by the owner. The practice in St. Thomas is to have repairs made by the corporation and charged against the owner.

2. Has there been any serious objection to the assessment of water mains against frontage? W. C. Smith, of Oshawa, pointed out that the whole matter of assessments is before the courts, while other members explained the various methods of assessment employed in their respective communities. In St. Thomas mains are not charged against property but are considered as part of the water-works system. In Winnipeg they are charged against capital, in addition to which a 4 ct. per foot frontage tax is charged in perpetuity. Kitchener's practice is for the water commission to pay in cash for flankage and intersection exemptions and for the city's share in parks, etc. A frontage assessment applies to private property. In Etobicoke township flankages are exempted for 100 ft., while according to a recent county judge's ruling, one-third of the flankage is exempted up to 120 ft. maximum.

3. When a customer complains of "poor pressure" how do you investigate? What criterion do you use for "good pressure?" W. C. Miller, answering this inquiry, said that he used a ¼-in. orifice with pressure gauge which is screwed on the service in the basement. If the pressure is 28 to 30 lb. it is considered sufficient. Alex Milne, of St. Catharines, thought that this pressure was too low. He uses a similar method of test but considers 45 lb. as the proper pressure.

4. In case of an admitted leak on a metered service, do you make any adjustment in the bill? In Chatham, Ont., rebates are refused unless the commission's officials were shown to be responsible for the leakage.

5. If a meter reader calls and the occupant is not home, should the householder be permitted to read the meter? Various practices were disclosed in the discussion on this subject. In some cases cards are left asking the owner to notify the water department when a meter reader may call. In others, the owner is asked to read the meter, while in still other instances, an estimate is made and a reading taken at the next regular reading period. The consensus was that the owner should not be allowed to read the meter.

6. What new maintenance equipment devices do you use to meet emergencies? The only piece of equipment mentioned was the air-operated paving breaker.

7. Have you used oak valve boxes, and, if so, do you find the frost forces the box down on the valve, causing damage to the pipe? T. H. Hooper, of Winnipeg, reported that this was the experience in Winnipeg. Sudbury had also had trouble in this direction, but since adopting telescopic iron valve boxes had not been bothered with frost.

8. Have you used copper service pipe for services, and, if so, what has been your experience; also what sizes of pipe have you used? Winnipeg is now using copper exclusively, having had no trouble with that type of pipe in the seven years since the first copper service was installed. R. H. Martindale, of Sudbury, said that his experience was the same. In reply to a question he said that no harm was done to copper by electrical methods of thawing. Another question asked about copper service pipes was if it was the general practice to carry them right into the house. From the replies it appeared that usually copper pipe is carried to the street line only. It will be taken into the house in many cases if a special request is made.

9. What system do you adopt regarding winter inspection of hydrants? Winnipeg's practice in this regard is to divide the city into zones and inspect daily in the downtown zone, and less frequently toward the suburbs. After a hydrant is used, it is inspected and repacked. In Sudbury, daily inspection is carried out, with a special inspection after a fire.

10. What system do you adopt regarding inspection of valves? One superintendent reported that valves on trunk mains are inspected and operated twice a year. In Sudbury an endeavor is made to inspect valves yearly.

11. Are contractors and others permitted to use fire hydrants for construction purposes, and under what conditions? What is the result of your experience where hydrants are so used? The general opinion was that hydrants should not be used by contractors, but should be operated only by water-works employees.

12. What proportion of the cost of replacing broken hydrants is charged to automobile drivers, and how do you collect this account? What means, if any, are adopted to protect fire hydrants from being damaged or broken by automobiles or trucks? The discussion on this question showed that the general policy is to charge the automobile drivers with the full costs of repairs. One method of protection that was advocated was the use of a 5 or 6-in. wrought-iron pipe buried in front of the hydrant.

Allowance for Swell in Scow Measurement

In the opinion of a special Committee on Rivers and Harbors of the American Railway Engineering Association, a fair allowance for swell in scow measurement of excavation by dredging, where measurements by soundings are impossible, may be as follows:

Hardpan and sand, 0 to 5 per cent,
Sand and gravel, 5 to 10 per cent,
Clay and hardpan, 10 to 20 per cent,
Ledge, clay or stiff mud, a maximum of 30 per cent.

The Use of Chlorine in Water Purification

Development of Chlorination for the Protection of Public Water Supplies—Importance of Continuous, Controlled Chlorination—Operating Records—Prechlorination and Preammoniation

By ARTHUR E. GORMAN
Wallace & Tiernan Co., Inc., Newark, N. J.

ALTHOUGH introduced primarily as a health measure—and still carried out as such—chlorination has been shown to have also a very definite economic value in the water-works and other sanitary fields. Today it is one of the best developed and carefully controlled phases of water purification.

Some idea of the importance and extent of chlorination may be obtained from the fact that in the United States alone, approximately 50,000,000 people drink chlorinated water. Over 82 per cent of all public water supplied in this country is chlorinated.

A high percentage of these supplies are of surface origin. It was only to be expected that these supplies would be the first to receive the attention of health and water-works officials, for they were practically all polluted or subject to pollution of a serious character.

The progress in chlorination of well supplies for health protection has been relatively slow. As a matter of fact, under existing conditions, with the strict supervision and high caliber of technical control over the purification of surface supplies—in spite of their known pollution—the product as dedelivered to the public, in many states is superior in quality to and may be considered a lesser public health risk than many well-water supplies in the same sections which are receiving no treatment and little supervision. In treating a surface supply the degree of contamination can be closely determined and the purification treatment controlled accordingly. With well supplies, especially of the shallow type, the degree of pollutional risk is unknown and serious contamination may develop when least expected.

The contamination of public water supplies from wells is, however, receiving more attention from health officials now than ever before. In a recent paper before the Missouri Valley section of the American Water Works Association, R. E. Lawrence, sanitary engineer with the Kansas State Board of Health, strongly emphasized the need for sterilizing well-water supplies. He shows that in Kansas the number of public water supplies from underground sources which meet the Treasury Department standards for safe water has decreased from year to year. Less than 1 per cent of these supplies have perfect records for eight or nine years.

The general recession of groundwater levels in the middle west is a serious water-supply and health matter. As underground sources decrease in available supply, the more inferior the water is likely to be. As wells go dry and become abandoned, a serious sanitary condition arises, for an abandoned well is a public health menace in a section where water is obtained from well supplies. Witness the recent typhoid epidemic at Fond du Lac, Wis., where 1,000 cases of dysentery, 50 cases of typhoid and 4 deaths resulted from pollution of the public water supply by grossly polluted river water entering an abandoned well. Some of the most serious waterborne typhoid fever epidemics of recent years have been caused by underground pollution of well-water supplies; viz., at Olean, N. Y.; Santa Ana, Calif., and Fond du Lac, Wis. Proper chlorination in any of these cases would undoubtedly have prevented sickness.

Corrosion, pitting or cracking of well casings, thus permitting surface water to leak into the well cavity of public water supplies, is a serious health problem. The facts obtained from a most thorough sanitary survey of a well from the surface cannot be depended upon to predict the quality of the water to be obtained from the well. In drilling a well pollution from surface source cannot be avoided. The better organized water departments are accepting chlorination of their well supplies as a justifiable health measure and a legal factor of safety well worth the investment.

Chlorination Policies.—In the two decades which have passed since chlorination of public water supplies was first introduced as a health measure, we have seen remarkable developments in methods, equipment and general policies concerning chlorination. Out of these years of experience, experiment and intelligent supervision have crystallized certain practices and policies well worth the consideration of all water-works and health officials.

Perhaps the most important development from the health viewpoint has been the universally wide acceptance of the doctrine that chlorination, where necessary as a health measure, must be a continuous process. This has come from several causes: serious outbreaks of waterborne diseases because of intermittent or interrupted chlorination, the patient and persuasive policy of public health engineers and the acceptance—after ample proof—on the part of water-works officials that intelligent chlorination is one of the best auxiliaries in modern water-works practice.

The attitude of leading water-works officials toward the doctrine of continuous chlorination is reflected in duplicate chlorinators and duplicate chlorination equipment at the better equipped plants. Today specifications for new or remodeled water works almost always call for duplicate chlorinator equipment throughout.

A logical second development in chlorination as a health measure was the growth of the policy of controlled chlorination. Supported with ample evidence of the value of chlorine in killing disease organisms in public water supplies, health and water-works officials saw the need of and sought for a quantitative measurement of the effectiveness of chlorination of specific waters. They wanted proof that a certain quantity of chlorine applied to a contaminated water was assurance of health protection. Of course, they had this in the results of bacteriological analysis of the treated water, if made. But this proof was difficult for the smaller plants to obtain. It was not available in less than 24 hours and usually could not be had until the second day after chlorination. The orthotolidin test for residual chlorine brought out by Ellms and Hauser and the development by Enslow and Wolman of a practical operating technic for plant control of chlorination based on residual tests gave controlled chlorination a real and effective beginning. Now we find practically every water-works plant applying chlorine on a scientific and intelligent basis, regulating the dosage to carry a prescribed residual chlorine content five or ten minutes after application and knowing in advance that this practice assures effective sterilization.

With the establishment and acceptance of the policy of controlled chlorination of public water supplies, typhoid fever rates in American states and provinces began to decline rapidly. Twenty years ago it was only the most optimistic health officer who dared predict a typhoid death rate for our large cities of less than 5.0 per 100,000 population. In 1928 there were nine cities in which no typhoid fever deaths were reported. Sixteen had rates of under 1.0 and twenty other rates under 2.0. Among these are such cities as Chicago, New York, Philadelphia, Detroit and Cleveland.

A third and orderly outgrowth of continuous and controlled chlorination is the keeping of accurate operating

records. In many of the large water purification plants it had been customary to keep careful and accurate operating records. Routine chlorination records were, therefore, kept as a matter of policy. This was not generally true at the average plant. But the situation has changed remarkably. Accurate records of chlorination are now recognized as more than routine operating data. They are insurance and legal protection—records which should be carefully preserved with copies filed officially with the state health authorities. In case of investigation of waterborne outbreaks they are of inestimable epidemiologic value. They are data capable of analysis in establishing operating principles which may be of substantial financial value.

The increasing demand at the modern water works for automatic recording instruments for power, pumping and filtration equipment is extending to chlorination. This has come about largely through the recognition by the water-works executive of the importance of continuous chlorination records to himself, his company and health officials. Through automatic recording weighing scales giving a continuous record of the rate of withdrawal of chlorine from containers, this demand is being partially satisfied at present. Experimental operation during the past year of equipment for automatically recording and controlling the residual chlorine in treated water was very promising. When such equipment is available continuous and controlled chlorination will be an established fact quite independent of human error and producing accurate operating records.

Chlorination Practices.—While chlorination policies have been molded through experience into well established channels, chlorination practices have been of a most varied nature. In the earlier days chlorination was used almost entirely as a final treatment in water purification—as a factor of safety. Today we find chlorination used in all stages of water treatment and even in the distribution system after the finished product has left the purification plant.

The application of chlorine at two or more points in a water-works system is a good practice which is becoming widely accepted. By splitting the chlorine dosage, it lessens the liability of interruption in chlorination, reduces the possibility of tastes and frequently improves the efficiency of other treatment processes—such as algae control, color removal and coagulation. The policy of the Indiana State Board of Health in recommending split chlorination with a small final application in the distributing pumps is an excellent one.

Prechlorination.—Prechlorination has undoubtedly been the most important development in chlorination since the introduction of this chemical as a health measure 20 years ago. By prechlorination is meant the application of chlorine to the raw water usually ahead of coagulation or filtration. It was first tried about 10 years ago and because of its proved economic value has been widely adopted. It is conservatively estimated that over 200 cities in America practice prechlorination for one purpose or another. With a heavily polluted raw water, prechlorination will effect a marked reduction in bacterial loading on filters, permitting them to be operated at uniformly economical rates. H. W. Streeter, sanitary engineer, U. S. Public Health Service, in a paper read before the Public Health Engineering section, American Public Health Association, at Minneapolis, in September, 1929, reports that a series of tests conducted by the service shows that the maximum raw-water B. coli index consistent with producing a final (rechlorinated) effluent conforming to the U. S. Treasury Standard could be increased from 10,000 per 100 cc. without prechlorination to about 25,000 per 100 cc. with prechlorination.

Prechlorination of water for both slow and rapid sand filtration will permit marked increases in filter runs. This means a saving in labor and wash water as well as better operation to meet peak demands on the plant. Substantial savings in coagulants, effective color removal and elimination of troublesome microscopic growths in basins and reaction chambers are among the more important economic and operating values of prechlorination. The quantity of chlorine to be applied will, of course, depend on the quality of water to be treated. For best results, enough chlorine should be applied to carry from 0.25 to 0.5 p.p.m. residual chlorine in the water.

Algae Control.—Algae control is another valuable economic service which chlorination gives to the water-works operator. Tastes and odors due to microörganisms in water are experienced at most plants and are a serious source of operating difficulties and consumer complaints. The quantity of chlorine used will depend on the number of types of organisms present. Obviously it is more economical and satisfactory to use chlorine to control the growth of microscopic organisms in water than to try to eliminate them after they have developed in larger numbers. Therefore the water-works official will do well to make simple microscopic counts of algae appearing in their water supply and govern the use of chlorine accordingly.

The usual taste-producing forms such as asterionella, tabellaria, synedra, melosira, synura, dinobryon, uroglena and aphanizomenon can be controlled by using from 0.5 to 1.0 p.p.m. of chlorine with residuals of from 0.2 to 0.5 p.p.m. Hale, of the New York Water Department, in a recent paper read before the New England Water Works Association, reports that chlorination of the Catskill aqueduct waters has reduced the annual tonnage of copper sulphate used for algae control from 38 to 53 and has shortened the time of treatment from a yearly average of 5 to 3¾ months.

Crenothrix and beggiatoa growths in mains and basins have been controlled by chlorine using 0.75 to 1.25 p.p.m. chlorine with residuals of from 0.3 to 0.7 p.p.m.

Chlorination will also kill larger microscopic forms such as small crustacea and nematodes. Cyclops and daphnia can be killed in less than 30 minutes with a dosage of about 1.0 p.p.m. chlorine. Nematodes or tiny worms which occasionally appear in water reservoirs have been killed using from 3.0 to 5.0 p.p.m. chlorine.

Preammoniation.—In the recent months there has developed a widespread interest among water-works officials in the use of ammonia and ammonia compounds in conjunction with chlorine to eliminate objectionable tastes in water. Tastes may be from three sources:

1. Chloro-phenol tastes usually resulting from pollution of the water by by-product coke plant wastes such as phenols, cresols, etc., and their combination with chlorine used for disinfection to cause highly objectionable "carbolic acid" tastes.
2. Mild but objectionable "iodoform" or medicinal tastes are due to phenol derivatives of one sort or another which are absorbed by the water and combined with the chlorine. These may be extracts from the roots or leaves of plants or trees on the watershed or in the reservoirs.
3. Typical chlorination tastes due to excessive use of chlorine.

McAmis, of Greenville, Tenn., and Spaulding, of Springfield, Ill., report excellent results in eliminating chlorophenol tastes by preammomiation. M. H. Braidech, of Cleveland, O., has carried out a very careful set of experiments on ammonia-chlorine treatment of water polluted with various concentrations of phenol and reports remarkable results in taste elimination. As high as 1.0 p.p.m. of phenol in Cleveland water produced no perceptible tastes when the water was treated with 0.5 p.p.m. ammonia and 0.3 to 0.5 p.p.m. chlorine.

The recent work on the ammonia-chlorine treatment of water both in this country and in Europe is most promising for taste prevention. The products formed by this combined treatment are chloramines. It appears important that the ammonia be added prior to the chlorine, also that the water treated be alkaline or nearly so in reaction, for chloramines apparently decompose in acid solutions and thus lose their stability and sterilizing powers.

Chloramines are said to have a bacterial effectiveness of over three times

of that of chlorine. However, their sterilizing action is slower but longer active. They are more stable than chlorine and apparently obtain their greater sterilizing powers from the fact that the chlorine in chloramines is not available for oxidation of organic matter and is therefore not quickly absorbed as is the case with chlorine.

Braidech applied 0.25 p.p.m. ammonia and 0.5 p.p.m chlorine with a ten-minute mixing period and two hours' detention and obtained excellent results with highly polluted water. In European practice the proportion of ammonia to chlorine has varied in the ratios 1:1, 1:2, 1:4 and 1:8. It is the writer's opinion that before the ammonia-chlorine process is introduced widely in American water-works practice, health authorities and water-works officials will want to learn considerably more of its value and effectiveness than is now known. Fortunately, important experimental work is being planned at Philadelphia, Erie and Lancaster, Pa.; Warren, Defiance, East Liverpool and Cleveland, O.; Burlington, N. J., and Springfield, Ill.

The economical and effective ratios of ammonia to chlorine, the proper time interval between application of chemicals, the effect of pH, the delay in and retention of sterilizing action, the best method of application and control of ammonia and comparative costs are all data very much in need of careful attention and checking before this new process is widely accepted, promising as it appears now.

The elimination of taste in chlorinated water has been successful by several other methods, but none has been adopted widely nor at this time gives as much promise of practical success as the ammonia-chlorine treatment. Super-chlorination and de-chlorination using sulphur dioxide has been successful at Toronto under the able direction of Howard. Toronto uses the super-chlorination process to eliminate chloro-phenol tastes when they occur, which is something over 150 days in a year. De-chlorination using sodium thiosulphate has been used some abroad, but in only a few places in this country. Permanganate-chlorine treatment has been used succesfully by Caird at Charlotte and Troy, N. Y., and by Harrison at Bay City.

The use of activated carbon for removing tastes in chlorinated water has received considerable attention during the last two years. Baylis of Chicago considers super-chlorination and de-chlorination by activated carbon to have excellent economic possibilities in water purification where the water to be treated is highly polluted—super-chlorination for bacterial reduction and removal of the chlorine and taste-producing chlorine products by passing the water through activated carbon filters. Cleveland, after considerable investigation of super-chlorination and activated carbon treatment, has gone over to experiments with ammonia-chlorine treatment for taste elimination as being the more practical for their conditions.

The absorption properties of activated carbon are remarkable and although the indications are that for larger-scale treatment the cost may be high, the process is worthy of much careful study, especially for smaller water plants. Baylis would first filter the treated water through sand filters and through activated carbon by upward filtration.

Main Sterilization.—In recent years more attention has been given to the quality of water in the distribution system than ever before. Water-works and health officials realize that from the consumer and public health viewpoint it is the water at the top which counts and not the water entering or in the clear well at the purification works. Carrying a slight residual chlorine in the distribution system of a water works has many advantages. It will help control bacterial after-growths; will give protection against possible contamination of the system by minor cross connections, of which type there are usually many known and unknown in every water works; it will control microscopic growths and especially the troublesome cronothrix.

The sterilization of new mains and yearly or semi-annual sterilization of a water-works distribution sytem is an excellent practice. The amount of pollution which may enter new mains under construction makes it a positive health hazard to put them into use for distribution of water unless they have just been sterilized.

Once pollution enters a distribution system, it is very difficult to eliminate. Even though no serious consequences result at the time, the system may become seeded with organisms of pollutional origin, making future bacterial samples from control points in the distribution sytem of doubtful value as a check on the quality of the water from the filtration plant and the existence of cross connections.

Many of the large cities, such as Chicago, New York, Philadelphia and Baltimore, have made it a practice for several years to sterilize new mains for health protection. The use of liquid chlorine applied either as a gas or a solution into the main through a corporation cock is fast replacing the early practice of using hypochlorite of lime. It has been found more convenient and reliable as the dosage can be controlled and the difficulty with lime-ash deposits in the system is eliminated.

Perhaps the largest main sterilizing project which has ever been attempted was carried out last month in sterilizing the new conduit of the North Jersey Water Co. from the recently completed Wanaque reservoir. This conduit from the Wanaque dam to Kearny, N. J., is about 25 miles long. It is of 84-in. steel and concrete with sections of duplicate 72-in. steel pipe. The chlorine as a solution was applied at the inlet to the conduit at the dam. The flow of the heavily chlorinated water through the new system is checked by making ortho-tolidine tests for free chlorine at sampling points along the main. Water was wasted into the Passaic River through a cutoff until the chlorinated water had passed through the entire system. About four days were required to sterilize this new system and the results were very satisfactory.

Conclusion.—In conclusion it may be said that chlorination has become a well established practice in water works. Introduced first strictly as a health measure, it has come to be one of the most helpful auxiliaries in water treatment.

The technic of chlorination has been highly perfected. The doctrine of continuous and controlled chlorination has found wide acceptance. Chlorination is now being carried out under technical supervision and control and the results of operation are being accurately kept and intelligently interpreted. They are valued as legal evidence of proper operation.

Chlorination has been found to have important economical advantages in algae control, improved filter plant efficiency, reduction of bacterial loading and control of troublesome after-growths in the distribution system.

It appears that the objections to chlorination due to tastes are likely to be overcome by either the activated carbon or the ammonia-chlorine treatment, both of which are now attracting wide interest.

Acknowledgment.—The foregoing paper was read before the Indiana and Southeast sections, American Water Works Association, at Lafayette, Ind., on March 21 and at Savannah, Ga., on April 15.

Gulls and the Contamination of Reservoirs

Contamination of the London water supply by gulls has been a problem for some years. The droppings of gulls, it is stated, contain at least a million B.coli per gram weight. Studies made at London reservoirs disclosed that the droppings of two gulls amounted to 157 grams in 24 hours. This means that each gull may contribute from 50 to 100 million B.coli per day. Biochemical investigations showed that no typhoid organisms were isolated from 626 colonies studied. At one reservoir, during the month of January, the surface was completely covered with gulls, rendering the water invisible. The systematic firing of guns each evening and —when found necessary—at other times was found to drive the birds away. The presence of the gulls in the reservoirs compelled chlorination as a precautionary measure.

Recent Trends and Comparative Costs of Sewage Disposal

Analysis of 48 Sewage Treatment Plants Shows Increasing Use of Mechanical Equipment

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THE marked trend toward the use of more mechanical appliances for the purpose of improving the efficiency of treatment and securing economies in land, structures and plant operation is perhaps the outstanding characteristic shown by a study of some 48 sewage treatment plants constructed in this country during the period from 1924 to 1930.

The purpose of this study was to determine what trends might be observed in general methods of sewage treatment and the facilities used therein. In order to secure an impartial list of plants a search was made in seven technical publications for plants constructed during the period previously referred to. In some articles it was apparent that not all of the facilities had been described, so a questionnaire was sent out showing those stated in the article and asking the person addressed to indicate any additional facilities which had been omitted, and also the first cost, operating costs, design, capacity and population served by the plant. Some thirty questionnaires were returned. In the letter transmitting the questionnaire, its purpose was described and the statement made that if the questionnaire was not returned it would be assumed that the facilities stated thereon were correct. This somewhat lengthy explanation of the source of information for the article has been made so that the reader may form his own conclusions concerning the accuracy of various portions of the data from which conclusions are hereafter drawn.

A list of plants, grouped by year of construction, is given in Table I. This table shows the facilities for treatment in the general sequence which the sewage follows in passing through the plant.

Any comparison of sewage treatment plants must be limited necessarily to general plant characteristics for the reason that local physical and financial conditions may not only govern the selection of a method of treatment but also determine the extent of application of the method. A statement of trends in treatment processes must be made with a full consideration of the important part which these local requirements play in selecting type and extent of treatment. For example, the use of a rapid sand filter following final settling facilities would not necessarily show a trend in a process, but would probably indicate a local condition which makes the addition of such a structure desirable. A general movement toward one process or another, or a general substitution or addition of an established or newly conceived facility for another, was considered in this investigation a trend.

Types of Treatment.—For the purpose of comparison these plants were divided into three groups according to types, each plant utilizing a portion or all of the facilities given in the following classification:

Type A.—Screens, grit chambers, Imhoff tanks, gas collection, sprinkling filters or contact beds, final settling tanks, chlorination and sludge drying beds.

Table I

SEWAGE TREATMENT FACILITIES IN PLANTS CONSTRUCTED DURING SIX-YEAR PERIOD 1924 TO 1930

Data Based On Descriptions in National Technical Publications, Bulletins, and Questionnaire

GORDON & BULOT ENGINEERS CHICAGO

YEAR	CITY	POP. (1920)	Screens: Bar; Plain	Screens: Mechanically Raked	Screens: Fine	Grit Chambers: Incinerator for Screenings	Grit Chambers: Plain	Grit Chambers: Dorr Mechanical	Grit Chambers: Detritus and Skimming	Skimming Tks: Plain Skimming	Primary Settling Tanks: Plain	Primary Settling Tanks: Dorr	Primary Settling Tanks: Link Belt	Primary Settling Tanks: Other Mechanical	Activated Sludge: Imhoff Tanks	Activated Sludge: Preaeration	Activated Sludge: Compressed Air Agitation	Activated Sludge: Mech. Agitation-Simplex	Filters and Disinfection: Sprinkling	Filters and Disinfection: Contact Beds	Filters and Disinfection: Rapid Sand Filtration	Filters and Disinfection: Chlorination	Final Settling Tanks: Plain	Final Settling Tanks: Hardinge	Final Settling Tanks: Dorr	Final Settling Tanks: Link Belt	Sludge: Separate Digestion Tanks: Plain	Sludge: Separate Digestion Tanks: Dorr	Sludge: Separate Digestion Tanks: Other Mechanical	Sludge: Disposal: Gas Collection	Sludge: Disposal: Sludge Drying Beds	Sludge: Disposal: Glass Covered Beds	Sludge: Disposal: Mechanical Dryers	Sludge: Disposal: Sludge Force Main
1924	Champaign-Urbana, Ill.,	26,117	■					■						■					■				■		■					■				
	Marion, Ohio,	27,891	■					■						■					■				■		■					■			◤	
	Hagerstown, Md.,	28,064	■					■	■							■			■						■					■				
	Lincoln, Neb.,	54,948	■								■								■								■			■				
1925	Highwood, Ill.,	1,446												■					■											■				
	Pleasantville, N. Y.,	3,590	■											■					■		■	■								■				
	Lodi, Cal.,	4,850			■											■			■			■			■					■				
	Worcester, Mass.,	179,754	■						■					■					■				■							■				
1926	Stroud, Okla.,	1,361	■				■							■					■			■	■							■				
	Hartford, Wis.,	4,515	■									■		■					■											■				
	Austin, Minn.,	10,118	■											■					■						■					■				
	Pomona, Cal.,	13,505	■											■		■			■				■		■					■				
	Canton, Ohio,	87,091	■				■	■						■					■				■							■				
	Schenectady, N. Y.,	88,723	■											■					■						■					■				■
	Trenton, N. J.,	119,289		■				■						■					■											■				
	Chicago, Ill.,	2,701,705	■				■	■				■				■			■						■					■				■
1927	Delaware, Ohio,	8,756	■											■					■				■							■				
	Fostoria, Ohio,	9,987	■					■				■	■						■						■	■	■			■				
	Holland, Mich.,	12,183	■					■						■					■			■								■				
	Fond du Lac, Wis.,	23,427	■									■							□									■		■	◤			
	Sioux Falls, S. D.,	25,202	■					■					■						■									■		■				
	Wichita Falls, Tex.,	40,079	■					■						■					■						■					■				
	Oklahoma City, Okla.,	91,295	■					■						■					■			■								■				
	Flint, Mich.,	91,599	■											■					■											■				
	Akron, Ohio,	208,435	■						■					■					■				■							■				
	Chicago, Ill.,	2,701,705	■					■		■				■					■											■				
1928	Gaithersburg, Md.,	729	■									■							■				⊡							■				
	Mercedes, Texas,	3,414	■										■				■	■					⊡						■					
	Antigo, Wis.,	8,451	■					■					■						■										■					
	Lawton, Okla.,	8,930	■				■										■						■			■			■					
	Tucson, Arizona,	20,292	■									■							■										■					
	Elyria, Ohio,	20,474	■					■						■			■								■				■					
	Durham, N. C.,	21,719		■			■	■						■					■										■					
	Bloomington, Ill.,	26,725	■					■						■			■												■					
	Madison, Wis.,	38,378	■					■				■							■						■				■					
	Decatur, Ill.,	43,818	■					■						■			■		■				■						■					
	Pasadena, Cal.,	45,354	■	■								■													■									■
	Charlotte, N.C. (Sugar Cr.)	46,338	■			⊠	⊠							■												■	■							
	Topeka, Kansas,	50,022		■			■		■					■																				
	Springfield, Ill.,	59,183	■					■						■			■												■					
	Chicago, Ill.,	2,701,705	■					■		■				■					■											■				■
1929	Frederick, Okla.,	3,822	■									■					■						■			■								
	Princeton, Ill.,	4,126	■					■						■																				
	Tenafly, N. J.,	5,650	■		■			■									■					■												
	Sedalia, Mo.,	21,144	■											■					■											■				
	Alliance, Ohio,	21,603	■					■								■			■											■				
	Aurora, Ill.,	36,397		■		□			■			■							■										■	■				
	Springfield, Mo.,	39,631	■					■						■					■										■	■				

□ Not yet Constructed
◤ Added since Plant Construction
⊠ Use Discontinued
⊡ Fiddler Sludge Collector

Type B.—Screens, grit chambers, single-story, plain or mechanical primary settling tanks, plain or mechanical separate sludge digestion tanks, gas collection, sprinkling filters, final settling tanks, chlorination and sludge drying beds.

Type C.—Screens, grit chambers, plain or mechanical primary settlin tanks, aeration tanks, either with compressed air or mechanical agitation, final settling tanks, aeration tanks, digestion tanks, chlorination and sludge drying facilities.

The number of plants falling into each of the three groups is as follows:

Type A.—Imhoff tank treatment, with various subsequent facilities for treatment .....21 plants

Type B.—Single-story settling, separate sludge digestion, with various subsequent facilities for treatment .....13 plants

Type C.—Activated sludge plants, including those with Imhoff tanks for primary settling .....14 plants

Table II gives the annual percentages of types of plants constructed during the six-year period.

It may be noted that the number of Imhoff plants reached a peak in 1925, exceeded the others for the two ensuing years, and then gave place to separate sludge digestion and to activated sludge types. Activated sludge, however, exceeded separate sludge digestion in 1928 and equaled it in 1929.

The total number of plants on which this table is based is believed to be too small to permit accurate conclusions to be drawn concerning a trend from one general method of sewage treatment to another. The figures for 1928 and 1929, which include a total of 22 plants, would, however, seem to indicate an increasing tendency to use separate sludge digestion and activated sludge in place of Imhoff tanks.

A comparison of plants by size of cities is given in Table III. The comparison is not strictly accurate in that the division of populations is on the basis of the 1920 census.

It may be noted that the popularity of Imhoff treatment increased with increasing population during the six-year period, reaching a proportion of two out of three in cities having populations exceeding 100,000. Separate sludge digestion (Type B plants) does not appear in the table in cities exceeding 100,000 population, but its popularity is indicated in cities of lesser size. It is interesting to observe that activated sludge is used in 42.8 per cent of those cities having a population less than 10,000; and that the percentage of plants in those cities falling between populations of 10,000 to 100,000 is 21.4 per cent, or approximately one-half of the percentage in the first group. For cities exceeding 100,000, however, the percentage increased to a proportion of one in three.

Table II—Annual Percentages of Types of Plants Constructed, 1924 to 1929

Year	Imhoff (Type A) Per Cent	Separate Sludge (Type B) Per Cent	Activated Sludge (Type C) Per Cent
1924	50	25	25
1925	75	0.0	25
1926	62.5	12.5	25
1927	70	30	0.0
1928	20	33.3	46.7
1929	14.3	42.85	42.85

Table III—Percentages of Type of Plants Constructed, 1924-1929, on Basis of Population of Cities

Population 1920	Imhoff (Type A) Per Cent	Separate Sludge (Type B) Per Cent	Activated Sludge (Type C) Per Cent	Total No. of Plts.
Below 10,000	28.6	28.6	42.8	14
10,000 to 100,000	46.4	32.2	21.4	28
Above 100,000	66.7	0.0	33.3	6

An examination of Tables I, II and III brings out a number of interesting facts which serve to establish several trends in the various steps in the treatment processes, to which reference is made in the following paragraphs:

Bar Screens, Incinerators, Grit Chambers, Skimming Tanks.—The inclusion of bar screens in 40 plants points to their usefulness in keeping large solids and coarse debris from the mechanical equipment in the plant. In several recent installations mechanical cleaning devices have been provided. It is of interest to note that only two of the plants are using fine screens. Both of these plants are of the activated sludge type.

Incinerators for screenings have been provided in eight plants, one of which reported discontinuing the use of this facility. This arrangement simplifies

Table IV

CONSTRUCTION AND OPERATING COST DATA
SEWAGE TREATMENT PLANTS CONSTRUCTED DURING SIX-YEAR PERIOD
1924 TO 1930

GORDON & BULOT
ENGINEERS
CHICAGO

Year of Const.	City	Design Capacity of Plant Mgd.	Design Capacity of Plant Pop.	Cost of Plant $	Unit Cost Based on Design Cap. Per Mgd. $	Unit Cost Based on Design Cap. Per Cap. $	Annual Cost of Oper. Excl. Fixed Chgs.& Depr. $	Population Served	Cost of Oper. Per Cap. Served $
			IMHOFF PLANTS						
1924	Marion, Ohio	4.0	40,000	539,200	134,800	13.48	19,000	25,000	.76
1924	Cham.-Urbana, Ill.		45,000	470,180		10.45		38,450	.36
1925	Pleasantville, N.Y.	.5[1]		125,000			3,700	1,900	1.95
1925	Worcester, Mass.	28.0		3,800,000	136,714		54,827	187,000	.29
1926	Stroud, Okla.	.15		25,000	166,667		250	2,500	.10
1926	Austin, Minn.	1.3		220,000	169,230		7,000	14,000	.50
1926	Canton, Ohio	13.5	135,000	922,879	68,361	6.83	36,006	100,000	.36
1926	Schenectady, N. Y.	8.0		400,000[4]	50,000		42,000	60,000	.70
1926	Trenton, N. J.	25.0		1,250,000	50,000		51,000	150,000	.34
1927	Delaware, Ohio		14,500	215,000		14.83	12,000		
1927	Holland, Mich.		22,000	220,785		10.03	9,390	14,500	.65
1927	Wichita Falls,Tex.	3.0		350,000	116,667		10,000	55,000	.18
1927	Akron, Ohio	33.0	260,000	3,644,000	110,424	14.00	59,650		
1927	Flint, Mich.	16.0		1,030,098	64,381		59,467	130,000	.46
1928	Bloomington, Ill.	5.5		700,000	127,272			40,000	
1929	Alliance, Ohio		36,000	490,000		13.61	17,250	41,000	.42
		PRIMARY SETTLING AND SEPARATE SLUDGE DIGESTION PLANTS							
1924	Lincoln, Neb.	4.5		440,000	97,777		22,000	80,000	.28
1927	Fostoria, Ohio	2.0		200,000	100,000				
1927	Pond du Lac, Wis.	4.0		155,000	38,750		15,457	27,000	.57
1927	Sioux Falls, S.D.	8.0		640,000	80,000		15,000	35,000	.43
1928	Tucson, Ariz.	3.56		75,000	21,067		2,400	47,500	.51[5]
1928	Durham, N. C.	2.0		190,000	95,000		7,000	16,000	.43
1928	Topeka, Kansas	5.4		312,500	57,870			54,000	
1929	Springfield, Mo.	4.5		225,000	50,000			40,000	
1929	Aurora, Ill.	7.0		600,000	85,714[2]			47,000	
		ACTIVATED SLUDGE PLANTS							
1924	Hagerstown, Md.	3.0		135,000	45,000		11,000	25,000	.44
1926	Pomona, Cal.	1.5		120,000	80,000		6,000	20,000	.34[6]
1928	Mercedes, Texas	.5		35,000	70,000			6,000	
1928	Elyria, Ohio		35,000	400,000		11.43	25,000	25,000	1.00[3]
1928	Pasadena, Cal.	8.5		771,000	90,705		113,032	120,000	.94[4]
1928	Charlotte, N. C.	5.0		310,000	62,000		38,000		1.17[3]
1928	Springfield, Ill.	3.75	30,000	355,000	94,700	11.83			
1929	Princeton, Ill.	.5		57,000	114,000		3,060	3,850	.79

1. Minimum
2. Estimated
3. Without Engineering Costs
4. Includes Trunk Sewer. Portion of Plant Constructed 1915
5. Sewage Farm
6. Reduced by Receipts from Sale of Sludge

the problem of disposing of the screenings and obviates the difficulties which occur with other methods of disposal. Of the eight plants having incinerators, three have made provisions for sewage gas firing.

More than half of the plants, 26 out of 48, have grit chambers. Fifty-two per cent of the Imhoff plants, 54 per cent of the separate sludge digestion plants and 57 per cent of the activated sludge plants have this facility. Mechanical equipment for cleaning these chambers has been used in only three installations. It is not clear whether this is due to a lack of necessity for such equipment or to its comparatively recent introduction. In general, grit chambers are not used to any extent in connection with separate sewer systems.

Skimming tanks are usually provided for sewages with a high content of domestic grease, industrial oily wastes or other floating materials which either interfere with the treatment process or are unsatisfactorily carried off with the plant effluent. It may be observed that those cities reporting the use of detritus and skimming tanks have a population exceeding 38,000. Sewages from cities of such populations would normally be expected to contain more of these objectionable wastes than the sewages from smaller cities. Clarifiers or thickeners in settling tanks are sometimes equipped with mechanical skimming devices which eliminate the need for separate skimming tanks, especially where the grease and oil content is small.

Imhoff Tank Treatment.—It may be noted that while the number of plants using Imhoff tanks in the treatment process exceeds either of the other two types—21 as against 14 activated sludge and 13 separate sludge digestion plants—their construction has decreased sharply since 1927. Only five Imhoff tanks have been installed since 1927 and one of these is for primary settling in an activated sludge plant. This may be due to a general acceptance of the activated sludge treatment and primary settling with separate sludge digestion as more satisfactory methods of treatment. Gas can be collected in a much more simple manner from separate sludge digestion tanks than from Imhoff tanks. Out of ten plants reporting facilities for gas collection, two have Imhoff tanks, one plant taking the gas from its Imhoffs and the other from separate sludge digestion tanks. The latter is an activated sludge plant in which the Imhoff tanks are used for primary settling.

Primary Settling, Separate Sludge Digestion.—Primary settling with separate sludge digestion is represented by 13 plants. In these plants all of the primary settling tanks are provided with mechanical thickeners, with two exceptions, one built in 1924 and another very small plant constructed in 1928. Separate sludge digestion tanks, on the other hand, have not been so extensively provided with mechanical equipment, although the tendency has been markedly in that direction since 1927. No plain separate sludge digestion tanks appear on the table for the past year.

Separate sludge digestion tanks in conjunction with Imhoff tanks have been used in one plant out of the 48 and that in connection with activated sludge treatment together with sludge drying beds. In general, separate sludge digestion tanks with Imhoffs are used to remedy operating difficulties with Imhoff installations.

Sprinkling Filters, Contact Beds, Final Settling Tanks.—Sprinkling filters have been installed in 24 plants out of a total of 48, indicating the popularity of this method of oxidation and stabilization of effluents. These filters have not been used in conjunction with the activated sludge process. One plant, however, uses a rapid sand filter following final settling. In view of the wide use of sprinkling filters, the very small use of contact beds—two plants out of the entire list—is evidence of a general opinion that they are not as satisfactory as the latter. It must be recognized, however, that among the factors which may make the use of contact beds desirable under local conditions are the low head requirements which may eliminate the need for pumping, their effectiveness in handling small and varying flows and the elimination of odors and flies.

The use of final settling tanks following filters or contact beds is shown to be a desirable practice. Eighteen out of the 26 Imhoff and separate sludge digestion plants (Types A and B) having sprinkling filters or contact beds are provided with these tanks. The need for this arrangement, of course, is influenced by the amount and character of diluting water into which the plant effluent will be discharged. Final settling tanks in the activated sludge process, however, serve another purpose and are therefore discussed in connection with that process.

Activated Sludge Process.—Of the 14 activated sludge plants appearing in Table I, 11 use compressed air agitation and 3 use direct mechanical agitation for the oxidation of the sewage. Mechanical agitation appears thus far to have been limited to those plants serving relatively small populations. It is interesting to note the marked change from Imhoff installations to activated sludge and separate sludge digestion (Types C and B) beginning with the year 1928. During the last two years seven of the compressed air agitation plants and all of the mechanical agitation plants have been constructed. There is no evidence that the population of the cities using the activated sludge method of treatment is a guiding influence in the selection of this treatment; nor is there anything to indicate that the activated sludge process is gaining favor more rapidly than primary settling with separate sludge digestion followed by sprinkling filters.

With one exception all primary settling tanks shown in the table as adjuncts of activated sludge plants are mechanical equipped for sludge removal. Two plants use Imhoff tanks for primary settling, one of them, already referred to under Imhoff treatment, having separate sludge digestion tanks in conjunction with it. Plain separate sludge digestion tanks are provided in seven plants.

A study of the final settling tanks, which are necessary to the activated sludge process, demonstrates the desirability of mechanical equipment for the scraping and collection of the sludge. No plain final settling tanks have been used in any of the activated sludge plants listed.

Gas Collection.—Sewage gas collection for the temperature control of sludge digestion, for plant heating, elimination of odors and other purposes is shown to be a valuable facility in sewage treatment. The relatively small investment in collecting equipment as against the value of the gas collected makes for a reduction of operating charges and an improvement in the efficiency of treatment. Eight plants out of a total of 22 listed as constructed in the past two years have been provided with means for gas collection; and to 2 plants constructed in 1927 this addition has been made recently. None of the 26 plants constructed prior to 1928 reported having this facility originally.

Chlorination.—The disinfection of sewage plant effluents by chlorination is provided for in 13 plants, or approximately one in every four. While it must be recognized that the need for chlorination is determined by the character and function of the diluting water receiving the plant effluent, yet the ratio of plants providing chlorination seems to indicate the desirability of this facility.

Sludge Disposal.—That sludge drying on sand beds remains almost a universal method of sludge disposal is shown by the large number of plants provided with this type of facility. Forty-five plants out of a total of 48 report air drying on sand beds. Of the three remaining plants, two pump the sludge to another plant and one uses a mechanical dryer.

The dehydration of activated sludge has been a problem since the inception of this method of treatment. Presses and sand drying beds have not proved entirely satisfactory in many instances. Out of the 14 activated sludge plants, 11 are using sand drying beds.

The use of hot-house type glass-covered beds—five installations in the past two years—indicates that this adjunct to drying beds is considered to be of merit.

Plant Costs.—The cost of treatment

plants is influenced by many factors pertaining to local conditions in addition to labor rates, material prices and land values. The character and volume of the sewage and trade waste to be treated, the amount of dilution available for the plant effluent, the topography of plant site and its elevation relative to the sewerage system, the proximity of the plant to water supply sources and residential and recreational districts, and the geographical location of the city are important factors which respectively influence the size and type of plant and the necessity for pumping, chlorination, filtration and other requirements, all of which are reflected in construction costs. It is probable also that the first costs reported for the plants studied in this article do not include uniformly the items of preliminary costs, land and overheads. For all of these reasons it is difficult to compare one plant with another, either on the basis of unit costs or of operating expenses.

Table IV gives the unit-cost of plants per capita or per million gallons daily of design capicity, and the operating expenses per capita of population served. These figures, though not suitable for close comparison, indicate a range of unit costs, both of construction and operation, for each of the three groups of plants. In view of the number and size of plants under consideration and their geographical spread, these ranges of cost may indicate the limits within which many of the plants to be constructed in the immediate future would fall.

While it is recognized that for a fair comparison a unit of plant cost should be based upon the total capacity of the plant, expressed either in cost per million gallons daily capacity or per capita of design population, yet the cost of a plant per capital of served population is of interest. The total investment in plants for which population served is known amounts to $14,698,642. The total reported population served by these plants is 1,405,700, from which the average cost per capita served is found to be $10.46. Attention is called to the fact that the reported population served is not to be confused with the census population.

By assuming an average sewage flow of 100 gal. per capita per day for plants whose design capacity in millions of gallons daily only is known, and determining therefrom the equivalent population which these plants can serve, we find that provision has been made for 2,091,600 persons at a total investment of $19,422,642. On the basis of the foregoing assumption the average unit-cost of all plants per capita of ultimate design population is therefore found to be $9.29. Likewise the average unit-cost of plant per million gallons of plant capacity is $89,542. For Imhoff plants the unit cost of plant per capita is $10.09; for activated sludge plants, $8.56; and for separate sludge digestion plants, $6.93.

The total annual cost of operation, exclusive of fixed charges and depreciation, of those plants for which the served population is given, is $529,839. With a total served population of 1,180,250, the average unit-cost of operation is $0.45 per capital served. A summary of unit-costs is given in Table V.

Table V—Summary of Unit-Costs

Cost of all plants per million gallons daily capacity	$89,542.00
Cost of all plants per capita of design population	9.29
Cost of Imhoff plants per capita of design population	10.09
Cost of activated sludge plants per capita of design population	8.56
Cost of separate sludge digestion plants per capita of design population	6.93
Cost of all plants per capita of served population	10.46
Cost of annual operation per capita of served population	0.45

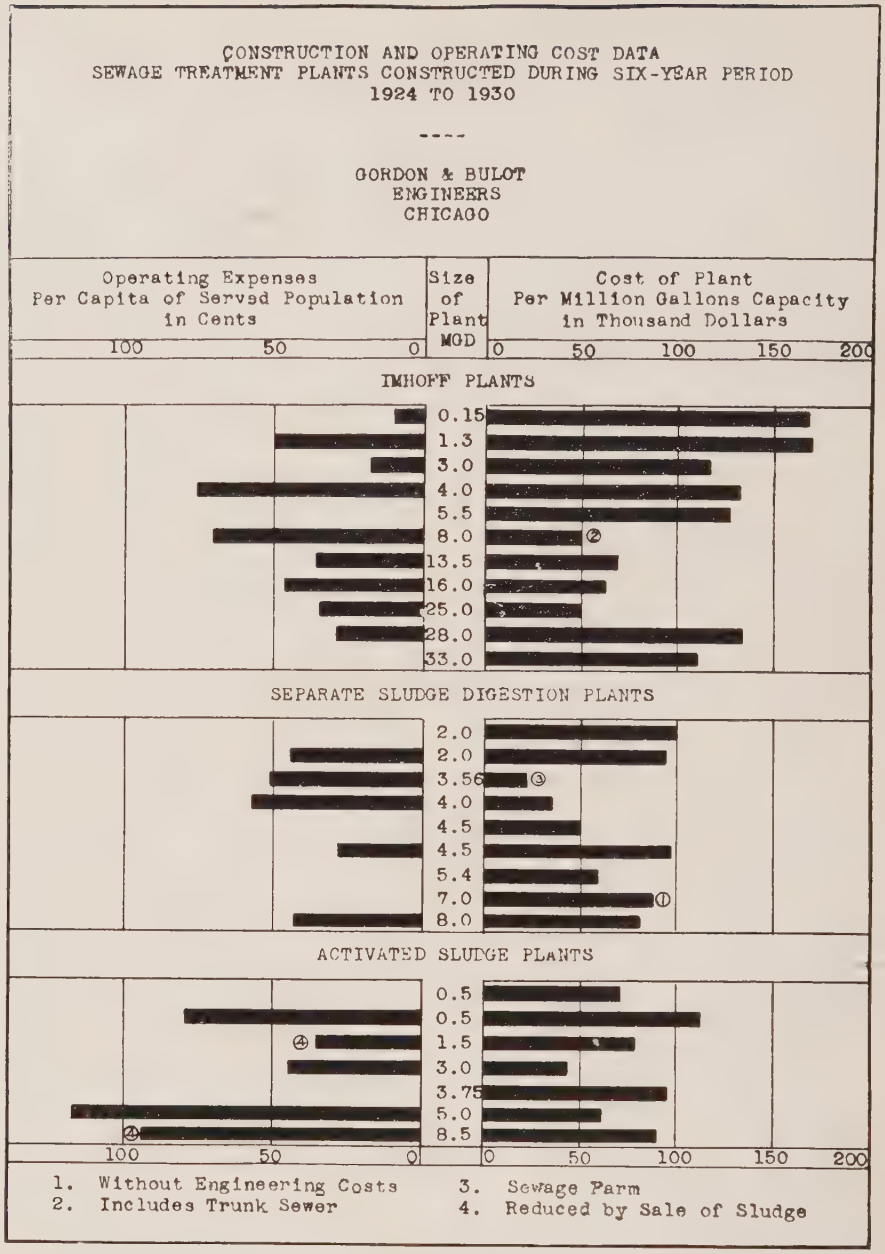

Fig. 1

Figure 1 is a graphical representation of a comparison of unit plant costs with corresponding annual per capita operating expenses for plants of each type for which data were available.

Trends.—The general trend in sewage treatment on the basis of this analysis is toward the use of mechanical appliances. A large amount of mechanical equipment has been developed in recent years, some of it original and some of it taken from other industrial processes, such as mining, paper making and refining. Much of this equipment improves the efficiency of treatment and provides economy of space, thereby reducing construction costs. Any reduction in manual labor should influence the operating costs provided that power cost and requirements are not excessive. The interest of both sanitarians and manufacturers in this direction is manifested by the amount

of relevant material in the technical press.

The following observed tendencies may serve to point out this trend toward mechanical appliances:

1. The use of mechanically raked screens.
2. The use of sewage-gas-fired incinerators for screenings and débris.
3. The substitution of mechanically cleaned chambers for plain grit chambers.
4. The use of mechanical appliances for scraping and concentrating sludge in settling and sludge digestion tanks.
5. The use of appurtenances for the storage and utilization of sewage gas.
6. The use of chlorinating equipment for disinfecting plant effluents.

Several recurring plant features show tendencies toward changes or additions to treatment methods. Among these are:

1. Plain, single-story settling tanks in conjunction with separate sludge digestion tanks, used in place of Imhoff tanks.
2. Sprinkling filters used in preference to contact beds.
3. In the activated sludge process, the substitution of equipment providing mechanical agitation and surface aeration for blower equipment providing air diffusion.
4. The use of final settling tanks following sprinkling filters.
5. Provision for the chlorination of effluents.
6. Glass covering of sludge drying beds.
7. Sewage gas collection.

The trends set forth in this article are based upon a study of those plants given in the tables and from sources of information previously referred to. These plants, although only a portion of the total number constructed during the years studied, are believed to be representative in type, location and range of capacity and therefore do reflect general trends in sewage treatment for the six-year period.

Ontario Sewerage Systems.—In the province of Ontario there are now 95 public sewerage systems supplying a population of 1,800,000. Some of these systems are comparatively small and have been built because extensive treatment works were not required, while others involve many miles of sewers with modern disposal works. Forty-six sewage disposal plants are now in operation and six are under construction, and will be ready for operation shortly. The following table indicates the various types of plants in use in the province:

	Number of Plants	Per Cent of Total
Plain sedimentation	18	39
Imhoff tanks and filters	9	20
Activated sludge systems	19	41
Total	46	100

A. W. W. A. Membership Campaign Makes Good Progress

The 1930 membership campaign for the American Water Works Association, which got under way officially on March 25, has resulted in the receipt at headquarters, of applications for 109 new members with 8 reinstatements of old members.

While this is the largest number of applications received in any month in the history of the association, the returns are slightly less than the quota for May 1 of 150 new members, which was set by Chairman Arthur E. Gorman, when the campaign was being organized.

There is a great deal of interest in this campaign throughout the country and Secretary Beekman C. Little believes that by the end of the convention week in St. Louis, the campaign for 500 new members will be an outstanding success.

The returns to date are summarized in the following table:

Standing of Sections and States in American Water Works Association Membership Campaign as of April 30, 1930

Section	Quota	New Members	Per cent of Quota
California	25	6	24.0
Canada	30	2	6.7
Central States	40	14	35.0
Florida	15	5	33.3
Four States	55	7	12.7
Illinois	25	4	16.0
Indiana	20	3	15.0
Kentucky-Tennessee	20	5	25.0
Minnesota	12	0	0.0
Missouri Valley	30	5	16.7
Montana	6	2	33.3
New York	55	20	36.4
North Carolina	20	3	15.0
Pacific Northwest	15	9	60.0
Rocky Mountain	20	3	15.0
Southeastern	30	12	40.0
Wisconsin	10	1	10.0
Non-Organized States			
Foreign	5	2	40.0
Louisiana	5	0	0.0
Nevada	2	0	0.0
New England	25	5	20.0
Southwest (Texas, Oklahoma, Arkansas)	25	0	0.0
Virginia	10	1	10.0
	500	109	20.8

Pacific Northwest Section has got away to a very fast start with 60 per cent of its quota returned to date. This section has a reputation of being one of the liveliest sections of the American Water Works Association, having brought home the Hill cup for member attendance at the annual convention in 1929.

In the number of new applications received, New York State Section is in the lead with 20, or 36.4 per cent of its quota.

Central States Section is second with 14 members and 35 per cent of its quota. The New York State crowd is out to capture first prize, but W. C. Lawrence, who has been appointed general Membership chairman for the Central States Section, has perfected an excellent field organization and promises to set a stiff pace to all sections in this campaign.

The Minnesota Section is the only one to date from which no applications have been received.

E. L. Filby in Florida has been going strong after new members and has returned 33 per cent of the qouta for that section.

The active interest of W. H. Weir and H. F. Wiedeman of the Southeastern Section, with their various state membership committees, has resulted in 12 new members, representing 40 per cent of their quota.

Results have not been as satisfactory in the unorganized states, although the New England Section has done very well with 5 new members, or 20 per cent of its quota.

Although the direct mail campaign which is being conducted is at its halfway mark, those in charge of the campaign feel certain that the month of May will bring in at least 250 additional members. Everyone is behind the campaign. State Sections are organized, the Manufacturers' Association is supporting the campaign with their usual energy, while in the unorganized states interested key men are assisting in building up membership in these states. It is probable that with the increased membership which results from this campaign, that it may be possible to organize new sections in A. W. W. A.

Water Utilization in Boise River Basin, Idaho

Investigations indicate that there is a shortage in the water supply for irrigation on the lands in the vicinity of Boise, Idaho, about one year in three, and a severe shortage about one year in ten; but by using reservoir sites in the Boise River basin above Arrowrock, such shortages would be materially relieved, according to a report by W. G. Hoyt and L. L. Bryan, hydraulic engineers of the Geological Survey, U. S. Department of the Interior.

This report states that there are six available storage sites, at which 477,000 acre-feet could be stored. All of this storage would not, however, be necessary at the present time. Holdover storage of about 50,000 acre-feet could be used to advantage oftener than one year in three, and holdover storage of 100,000 acre-feet would provide 100 per cent supply for 85 per cent of the time.

Besides the storage sites there are in the Boise River basin 25 power sites, at which 44,200 hp. can be developed for 90 per cent of the time and 72,000 hp. for 50 per cent of the time.

These figures are taken from a manuscript report of 150 pages that includes a brief discussion of the geography, geology, vegetation, agriculture, mining activities and roads and trails, and a set of nine maps showing plan and profile of the Boise River and its principal tributaries and the suggested dam and reservoir sites.

Sanitary Specifications and Construction for Water Wells

Prevention of Conditions Responsible for Contamination Aim of Illinois Department of Public Health —Specifications, with Interpretations and Reasons for Adoption, for Drilled and Dug Wells

By HARRY F. FERGUSON and CLARENCE W. KLASSEN

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THE advance in sanitation, like advances in many other fields, has often been by jerks. A disastrous fire or serious accident brings about the adoption of safety measures, a scourge of malaria results in mosquito control, a devastating flood is followed by river control projects and like an epidemic of waterborne illness invariably leads to needed improvements in the water supply system. These disasters represent a loss to those involved but, combined with the improvements which they bring about, they avoid similar future loss to those who take advantage of the lessons taught. Experience is often necessary to point the way. Sometimes water supply experience comes high, the price being suffering and death. Fortunately there is a substitute—prevention before cure becomes necessary. The wide-awake, conscientious water-works men can more profitably take advantage of the experience of others.

During the past few years Illinois has experienced several serious waterborne epidemics of dysentery and typhoid with the usual percentage of deaths. Several other supplies were polluted but fortunately the governing officials acted upon recommendations of the sanitary engineers in time to remove the cause of pollution or to chlorinate the water and prevent serious outbreaks.

A few of these pollution cases stand out as classic examples of well pollution. The importance of the protection of this particular type of water supply is often overlooked by some water-works men. A well might be so located and constructed so that at any time it could become polluted, yet the fact that it has not caused any waterborne illness develops a false sense of security in those responsible for the supply. With some, the erroneous impression still prevails that the mere fact that water is being pumped from a well gives definite assurance of its safety.

In Illinois 508 municipalities have public water-works systems which are supplied from 470 sources, some cities obtaining their supplies from other cities. The importance of wells and their construction and protection, as sources of public water supplies will be appreciated when it is noted that 371 of these sources are wells. Because of the common use of the automobile and the increased travel to and visiting in cities, the safety of public water supplies is of vastly more concern than just to the cities served by them. Combined with this travel and the geographical distribution of such well-water supplies, not only one community nor one state, but whole states are affected by the safety of public supplies. Because wells do play such an important part it is highly imperative that water-works men not only properly maintain but also give attention to the proper location and construction of such water supply sources when they are installed so that a clear, clean, safe water will be assured.

The Division of Sanitary Engineering makes inspections of all the Illinois public water supplies. These inspections reveal that in some instances considerable thought was given to the location and construction of wells, while others give evidence that the same type of thought was exercised in locating wells as is practiced in India, where it is reported that in deciding upon a well's location, several buckets of water are first thrown upon a goat, which is considered a sacred animal. The goat is then set free to run and is followed by the townsfolk. The point at which the goat first stops to shake himself marks the location of the well, whether it is in a field or the center of main street. In many modern developments of unsatisfactory wells, thoughtlessness, carelessness and false economy often dominate. In some cases wells are finished and equipped or covered in such a manner that improvements necessary to protect them against contamination become difficult and expensive.

Many of the unsatisfactory conditions of wells are caused by neglectful operation but in most cases the defects allowing the entrance of contamination could have been prevented and eliminated when the wells were installed. The fault may have been ignorance of the well contractor in sanitary precautions necessary for the protection of the well or of the engineer or municipal official in not including in the specifications sections covering the proper sanitary construction.

To prevent such conditions which are responsible for contamination instead of merely trying to correct them has been the aim of the State Health Department. It has been found through experience that it is not only easier but much more satisfactory to prevent than to correct, and thus municipalities, water-works officials, engineers and well contractors are being advised and urged to prevent conditions in water wells which might cause pollution of supplies and resulting epidemics rather than try to correct such conditions after the damage is done. Pursuing this policy, about three years ago, a suggestion by the state sanitary engineers to the professor of sanitary engineering at the University of Illinois brought about the organization of the Illinois Water Well Drillers Association and through the medium of their annual meetings it has been possible to inform and advise this group regarding the sanitary location and construction of water wells.

Municipalities, through their water departments, often enter into contracts for wells where the specifications are limited and incomplete. Major sanitary phases may be covered but minor questions of sanitary construction—those features which may seem unimportant, yet which are capable under certain conditions of causing serious pollution—are not included. This is not a theoretical viewpoint, for in our review of numerous specifications for proposed wells it has been found that those sections pertaining to the sanitary features of location and construction are not only incomplete but often entirely omitted. In such instances the municipalities must rely on the judgment, ability and integrity of the well contractors to locate and construct wells which will yield safe water. The average well contractor no doubt desires to construct safe wells but these desires are not realized, either on account of not being fully qualified, or, as in all fields, because those qualified may not be adverse to taking advantage of the municipality when incomplete specifications and contracts form the basis for the work.

On the other hand, it is unsatisfactory and unfair for a municipality to specify rigidly the location, casing and detail construction of a well and then attempt to have the well contractor guarantee the quantity and the sanitary and mineral quality of the water obtained. It is not only unfair to the driller but unsatisfactory to the municipality. In such instances, the driller

must necessarily make his bid sufficiently high to protect himself, for he naturally cannot change the character of the underground formations. His perhaps justifiable high bid not only protects himself on that particular job, but acts as a reimbursement on other similar jobs which have proved unsuccessful under those terms.

Based upon the past experience gained in field inspections, laboratory studies and review of specifications for wells, the need and use for some standards or minimum sanitary requirements for use by water-works men are apparent. Previous court decisions in Illinois and other states leave no doubt as to the legal responsibilities of municipalities and water companies for the safety of public water supplies.

Pursuing the policy of cooperation with engineers, well contractors and water-works men in preparing specifications for proposed new wells and determining whether the present wells are pollution proof, the Division of Sanitary Engineering of the Illinois Department of Public Health has prepared "standards" or specifications for proper well location and construction from the sanitary viewpoint. The specifications are composed of sections designed to be incorporated in general well specifications and include only those features which have an effect upon the sanitary quality of the water.

These specifications have gradually been built up and the ideas embodied therein are not based upon hypothetical possibilities of well pollution but upon actual field conditions illustrating how wells have been, are being and can be polluted.

In the "standards" or specifications accompanying this paper there have been included after each item of the specifications the public health reason and the "satisfactory compliance" or the conditions which satisfy the specifications. These were so written for a triple purpose: (1) that the specifications might be of value and use to the engineer, contractor or water-works official in drawing up and including the essential sanitary features in general well specifications; (2) that the public health reason might give information of educational value to engineers and municipal and health officials, and (3) that the "satisfactory compliance" might be a guide or "sanitary yardstick" by which water-works men can "measure" the sanitary features of their present wells and answer the question, "Are the wells pollution-proof?"

I. Drilled Wells

A. Rock Wells

1. **Location.**—(a) Surface drainage, flood water: The well shall be so located as not to be subject to surface drainage or flood water.

Public Health Reason: All surface water is contaminated, the nature of the contamination depending upon the character and amount of objectionable impurities with which the water has contact. Flood water often contains sewage.

Satisfactory Compliance: Location should be where ground does not become waterlogged at certain seasons, where the elevation is above maximum high-water level of nearby streams and where the surface drainage is away in all directions.

(b) Cesspools, privies: The well shall be so located as not to be subject to seepage from cesspools, privies, sink-holes or any accumulation of waste.

Public Health Reason: Seepage from cesspools and privies always contains, and seepage from sink-holes and accumulation of waste may contain organisms of intestinal origin which are capable of causing waterborne illness.

Satisfactory Compliance: Safe distance from a well to such sources of pollution depends upon the character of the upper strata at the location. A privy or cesspool should always be at least 75 and preferably 100 ft. away with natural surface drainage away from the well. In creviced limestone there is no safe distance and proper construction of the well must eliminate the danger.

(c) Sewers: The well shall be so located as not to be subject to seepage from sewers or tile lines carrying cesspool or septic-tank effluent.

Public Health Reason: Sewers carry animal and human wastes and seepage therefrom contains dangerous organisms.

Satisfactory Compliance: The safe distance from sewer to well depends on the character of the upper strata at the location, but all sewers, tile lines carrying cesspool or septic-tank effluent and connections from pumping-station toilet to street sewer should be constructed of cast-iron pipe with joints caulked watertight for a distance of at least 50 ft. from the well. In creviced limestone there is no safe distance. No sewer lines, regardless of construction, should pass within 10 ft. of the well casing.

(d) Abandoned wells: The well shall not be subject to seepage from abandoned wells.

Public Health Reason: Abandoned wells open at the top or those with defective casings allow the entrance of surface and shallow ground water which often finds its way to the water-bearing strata of the wells in use.

Satisfactory Compliance: The safe distance between abandoned wells and those in use depends upon the condition of the casing and construction of the abandoned wells and the strata they penetrate. Abandoned wells which are situated and constructed so that contamination may enter them and reach the well in use, should be filled with concrete, puddled clay or some other nonporous material or should be plugged at a depth or sealed so as to prevent possible contamination of the water-bearing strata. Whenever any well is abandoned, it should be plugged or sealed as described above and should never be used for the disposal of wastes.

2. **Construction.**—(a) Casing material: The casing shall be of such material that when in place it will be watertight its entire length.

Public Health Reason: Defective and leaky casings allow polluted shallow ground water or water of an undesirable quality to enter the well.

Satisfactory Compliance: Materials for casings are cast iron, wrought iron and screw-joint steel. Riveted steel or slip-joint pipe is generally unsatisfactory, as riveted pipe leaks along the seam and slip joints are not always watertight.

(b) Length of upper casing: The upper casing shall be of a sufficient length to penetrate a solid rock formation and be sealed into this formation so as to exclude any water from above seal entering around and directly under the seal.

Public Health Reason: Water in ground above such a seal is generally polluted or subject to pollution which can travel down on the outside of the casing and enter the well if the casing is not properly sealed into a solid rock formation.

Satisfactory Compliance: A suitable formation is that classified as "solid rock" by geologists and into which the casing is sufficiently driven or so sealed with grout or a lead or expanding-rubber packer or similar device that no water above and around casing can enter the well at the seal.

(c) Corrosion of casing: Casing extending through corrosive strata or water shall be protected from same.

Public Health Reason: Corroded casing allows the entrance of water of undesirable mineral and sanitary quality.

Satisfactory Compliance: Prevention of corrosion can generally be accomplished by installing a shell of cement or asphalt grout around the casing by leaving at least a 2-in. annular opening between the casing couplings and the drill-hole wall for grout. When replacing a corroded casing, the old casing should be removed and the drill hole reamed out to proper size for the cement grout shell, or a casing of lighter material installed inside the corroded one to act as an inner form for the grout. This latter method, of course, reduces the size of well. Corrosion can be reduced in new wells by installing cast-iron or genuine wrought-iron pipe to which has been applied a double coating of bituminous material.

(d) Closing casing after drilling: Upon completion of drilling, the casing top shall be cut off level and tightly closed until the pump is installed.

Public Health Reason: With the casing open, accidental or malicious contamination of water-bearing strata can result and unless the casing is cut off level, the proper sanitary method of

closing the top after installation of the pump cannot be accomplished.

Satisfactory Compliance: A cap screwed on to or a wooden plug driven securely into the casing is satisfactory. A plank, burlap, sack, etc., is unsatisfactory.

3. **Pits.**—No pit shall be left permanently around the casing top and the casing shall end at least 6 in. above pumping station floor, which floor shall be at least 12 in. above the ground surface.

Public Health Reason: Pits collect waste material, station floor drainage, oil, etc., which can enter an open casing top ending in a pit.

4. **Pump Connections.**—(a) Deep well pump, air lift: A watertight connection shall be made between the drop pipe and the casing top.

Public Health Reason: An annular space between the casing top and the drop pipe allows dirt, oil and waste pumpage to enter the well when the opening is not closed watertight.

Satisfactory compliance: Safe closing of the space can be accomplished by devices sold with the pump installed or by placing a lead seal between the drop pipe and the casing top. When the well has an outer casing the annular space between both casing tops should be closed.

(b) Pump discharge above base: When the discharge is above the pump base, the casing or casings, if the well has an outer casing, shall extend as far as possible into the pump base so as to cover effectively the annular space between casing tops and there shall be no hole in the pump base so located as to allow any oil or water to enter well.

Public Health Reason: Pump bases very often act as collectors of oil and waste pumpage which should be drained away from the well and prevented from entering around the drop pipe.

(c) Breather or vent pipe: Any breather or vent pipe which taps the casing or extends through the seal or connection at the casing top shall end at least 20 ft. above the station floor, the end pointing downward and finely screened.

Public Health Reason: Such vent pipes, unless properly protected, allow dirt and dust to enter the well.

(d) Sampling faucet: On the discharge pipe of each well pump shall be an approved tap for the collection of samples.

Public Health Reason: Regular sanitary analyses are advisable in keeping an analytical check on the quality of the water direct from each well.

5. **Sterilization.**—New wells, repairs: Before either a new well or one having been repaired is placed in use, the well shall be sterilized.

Public Health Reason: Contamination due to the newness of the material or that introduced by workmen during the installation of a pump in a new well or repairs on old well often persists for long periods of time unless the well is sterilized.

Satisfactory Compliance: Sterilization can be accomplished by adding chlorine or a solution of chloride of lime to the water in the well and allowing it to stand for several hours before the pump is put into operation. The water as discharged should show a residual of at least 0.3 p.p.m.

B. Drift Wells

The location, general construction and equipping of drilled drift wells is practically the same as for the rock wells with the following exceptions.

(a) Length of casing: The casing shall extend to the water-bearing strata.

Public Health Reasons: Shallow ground water above the water-bearing strata is often subject to pollution and should be excluded from the well.

(b) Gravel packed wells: In wells where gravel is fed between inner and outer casings, the outer casing shall penetrate an impervious stratum sufficiently to prevent water above the impervious stratum from entering the well, and the annular space between the drop pipe and both casing tops shall be closed watertight.

Public Health Reason: Water above the first impervious stratum is generally subject to contamination and unless the outer casing is properly extended into an impervious stratum and closed at the top, shallow ground water or surface contamination can enter the gravel and follow down to the screen and into the well.

Satisfactory Compliance: An impervious stratum such as clay, may sometimes not be encountered and in such cases the outer casing should extend to the water-bearing strata.

II. Dug Wells

A. General

(a) Location: Same as for drilled wells.

(b) Wall or curbing material: The wall or curbing shall be of such material that when in place it will be watertight to the water-bearing strata to be drawn upon and shall in no case extend less than 10 ft. below the ground surface.

Public Health Reason: Shallow ground water above a depth of 10 ft. is generally polluted and should be excluded from the well.

Satisfactory Compliance: Material for such wells is concrete made watertight by adding from 4 to 8 lb. of hydrated lime per sack of cement or by other approved waterproofing compound.

(c) Manhole openings: Manhole openings shall have sides raised at least 3 in. above the well top and shall be closed by a cover having overhanging sides.

Public Health Reasons: Manhole openings not adequately protected allow dirt and animal pollution, etc., to be washed into the well.

Satisfactory Compliance: Manhole covers can be made from concrete or metal-covered wood. Wooden covers are not satisfactory. Provision should be made to keep covers locked.

(d) Vents for air release: Vent pipes for air release shall be protected from allowing contamination to enter well.

Public Health Reason: Improperly constructed vents allow dirt, dust, bugs and bird pollution to enter the well.

Satisfactory Compliance: Pipes should end in a reverse turn pointing downward with the end at least 12 in. above the well top and covered with a fine copper screen.

(e) Suction pipe openings: Openings for suction pipes shall be so constructed as to prevent entrance of dust and dirt, etc.

Public Health Reason: Suction pipe openings when not properly constructed in the well top or side allow an avenue for the entrance of contamination.

Satisfactory Compliance: One method for constructing suction pipe openings is by placing in the forms short lengths of pipe larger in diameter than the suction pipe when the top or side is poured. The annular space between the suction pipe and the opening is caulked watertight with lead.

(f) Pumping machinery installation: Pumping machinery shall not be installed so as to necessitate the entrance of the operator into the well.

Public Health Reason: Persons entering the well track and otherwise cause the entrance of contamination.

Satisfactory Compliance: Pumping machinery should be located outside of the well.

B. Wells Not Covered or Partially Covered by Building

(a) Walls and top: Walls or curbing shall extend at least 3 ft. above the ground surface at the well and shall be covered by a properly draining watertight concrete top.

Public Health Reason: All possibilities of surface water, dust, dirt, animal and bird pollution entering well should be eliminated.

(b) Manhole openings, vent pipes and suction pipes, as previously described above.

C. Well Covered by Building Whose Foundation Is Continuation of Well Walls

(a) Walls and top: Walls of well shall extend at least 1 ft. above ground surface and shall be covered by a watertight concrete top.

Public Health Reason: The watertight well walls extending above the ground surface protect the well against allowing the infiltration of shallow ground water and eliminate the problem of having to drain a sub-ground pump room.

(b) Manholes, vent pipes and suction pipe openings should be constructed as described above.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor

Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

Odors from Sewage Disposal

THE subject of odors is always a pertinent one in connection with that of sewage. It seems more than likely that it was odor which first drew attention to the subject of sewage disposal. We know that it was the odorous condition of British streams, befouled with human excrement reaching them through the storm-water drains, that led to the first attempts at sewage treatment in England.

Ten years after the establishment of the first disposal works under compulsory legislation it was odor which led to an investigation to determine whether the condition produced locally by such works was not worse than the original condition of the rivers which it was intended to improve.

One has only to recall a soft June night in the country, a little vine-covered house at the end of the grape arbor bathed in moonlight and filling the glorious night with fragrance, to wonder that a disposal plant representing, say, a thousand or ten thousand such places can be made approachable.

Fortunately it is not true, as I once heard a specialist infer in court that if a 1-m.g. plant could be smelled at a distance of one mile (which it sometimes can), a 10-m.g. plant could be smelled at ten miles.

In fact, with the information and apparatus now available, it is possible to operate a plant of any size, under favorable conditions with no more fragrance than emanated from the little vine-clad wart at the end of the arbor.

Since those mellow June nights, with their odor-carrying propensities, are again upon us, it seems apropos to speak of odors.

Odors may be divided into two classes:

1. Local odors.
2. Migrating odors.

Local Odors.—Local odors are such as can be noticed only in the immediate vicinity of the operating structures. They may range from the odor of fairly fresh sewage, which is not particularly objectionable, but has a peculiar property of arresting attention whenever encountered, to the nauseating odor of rancid grease.

Normal Sewage Odors.—The milder odors, fresh sewage and wash-water odors, are inherent in the sewage and can only be made less noticeable by the use of deordorizers, such as chlorine products and phenol products. The effect of chloride of lime in making the atmosphere of pump stations and disposal plants somewhat more pleasant is well known. Perhaps more familiar are the naphthol products used about public toilets. As to the latter making the atmosphere more agreeable, that may be a matter of personal opinion. The writer's opinion would be in the negative in most cases. There are a few good deodorants, such as Phinotas, which really have a pleasing effect.

Preventable Plant Odors.—The stronger and really troublesome local odors usually come from the exposure of sewage solids and particularly grease to the atmosphere. The obvious remedy in this case is scrupulous care in keeping all solids submerged.

An ounce of solid material dropped from a rake or skimmer and allowed to dry on the tank wall may create more odor nuisance than all the remaining units of the plant combined.

A ring of grease on a tank wall between the high and low water lines and even creeping a little above the high water line will, when baking in the heat of a calm summer afternoon, cause very offensive odors. Possibly worse, because the area exposed is greater, is the odor from partially-dried scum floating on the surface of a tank and also baking in the sun. If the tank happens to be a humus or resettling tank following sprinkling filters at a time when the latter are unloading a mass of dead worms, the result will be the ultimate in choice odors.

Grease rings at the flow line should be kept down by constant scraping and scum blankets should be avoided wherever possible. Where it is impossible to eliminate such scum blankets—a thing that often happens under practical working conditions—it will help considerably to keep such surfaces thoroughly wet down. Chloride of lime and Phinotas powder, sprinkled on such exposed surfaces, have proved to be great aids in lessening the local nuisance.

If the scum blanket consists of sour, unripe sludge, the odor may become a migrating one under certain atmospheric conditions. Under such atmospheric conditions difficulties have been experienced with this sour, garbage-like odor at distances of one-fourth of a mile from a plant. It is possible for odors from such sour scum blankets to be carried to a considerable distance during evening and early morning hours, although the odor may not be particularly noticeable during the day even at close range. This condition of the scum blanket will be indicated by the visiting of certain insects that look much like honey bees but are four to five times as large as the latter.

Exposure of unripe sludge on drying beds gives rise to conditions similar to those described in connection with scum blankets. The sickening odor will persist about such beds for months after the sludge has been removed unless care is taken to remove the last traces of the poor sludge from surrounding walls where it may have dried on in thin sheets and become scarcely distinguishable from the concrete to which it adheres.

If it becomes necessary to draw sludge of this type to drying beds, as is frequently the case under practical operating conditions, the addition of a solution of alum just as the sludge reaches the bed will practically eliminate the odor trouble as well as hasten the drying of the sludge. About 1½ lb. of alum should be used for each cubic yard of sludge. Sulphate of iron would be equally effective in reducing the odor.

Migrating Odors.—While the odors so far discussed are annoying close at hand, they would not, except for the odors of sour scum or sludge, be detected more than 50 yd. from the source and seldom that far.

Odors from the sour sludge or scum or from foam, which is in the same class, from massed solids floating in septic tanks in the raw state, from undigested activated sludge, from septic tank effluent exposed to the air especially if agitated and from stale sewage in general, have been recorded as carried for a distance of two miles un-

der certain conditions. Odors from sludge-drying operations employing heat have been noted at considerably greater distances than this in a few cases.

Odors do not reach such distances when disseminated equally in all directions because under this condition they would soon be diluted by the air with which they come into contact to such an extent as to become inappreciable.

Heavy winds tend to diffuse and disseminate odors so that such winds are not much of a factor in carrying odors to a distance. Light winds, on the other hand, may move the odor "cloud" in fairly straight lines and within a narrow path to a considerable distance.

The most favorable condition for odors to reach a great distance from the source is in a nominal dead calm. In such a calm there are, in fact, slight currents of air traveling at inappreciable velocities and within very narrow limits, possibly only a few inches in cross-section but moving to great distances without sufficient disturbance to cause any dissemination.

The writer has observed such currents only 1 ft. in depth by about 3 ft. in width traveling suspended about 6 ft. above the earth surface at distances of one-fourth of a mile from the source of odor. The conditions under which such currents are formed are the same as those forming smoke flags and cloud flags. It is by creating smudges at the source of odor that the limits of these currents have been so accurately observed.

Probably all are familiar with the long trails of smoke (smoke flags) which, in the calm of a summer evening, or possibly on a still, hot afternoon, emanate from bonfires and hang suspended in mid-air. The study of these smoke flags has yielded much information on the travel of odors and has proved highly interesting.

One finds that from a given position these smoke flags will take the same definite course day after day, as if there were invisible banks to guide them. They do not come into actual contact with any object in their path, but pass around such objects at a definite distance in either a horizontal or vertical plane. The accompanying illustration shows the vertical profile of one flag that was repeatedly reproduced on successive summer evenings of like atmospheric conditions.

If there were sufficient movement of the current of air to cause it to impinge upon objects, such as trees, which it approaches, the odor cloud might be broken up and diffused, but there is no such velocity and this fact explains why plantings of trees and shrubs may not be effective in preventing the migration of odors.

On one summer evening during the course of these observations I noted mist rising from the ground surface of a certain field. Starting at the ground surface the mist slowly increased in depth until it topped a 3-ft. hedge along one side of the field. The mist then poured over the lowest portion of the hedge exactly as water would pour over a spillway and, turning, drifted down a road at right angles to its course over the hedge.

From these observations one must conclude that while shrubbery most certainly adds to the attractiveness of a plant it cannot be depended on as an odor screen.

Control of Stale Sewage Odors.—A large amount of work done by the Chlorine Institute under the direction of Linn H. Enslow has shown very definitely that the migrating odors from stale sewage are due to hydrogen sulphide and allied compounds which have a great avidity for chlorine, and that it is entirely feasible to chlorinate the sewage at some advantageous point in the disposal works or in the outfall sewer, thus "oxidizing" these compounds to inoffensive chlorine combinations.

The writer has demonstrated that by giving about 25 per cent of the sewage (settling-tank effluent) a partial activated sludge treatment and returning the aerated effluent with some of the sludge to the main flow of sewage before it goes to sprinkling filters, the offensive gases are sufficiently oxidized to eliminate dissemination of odors from the filter sprays.

In either the chlorine or activated sludge method the point is that the free hydrogen sulphide is reduced to so low a concentration that it is not offensive. W. J. O'Connell, Jr., gives this concentration as ½ p.p.m. With the chlorine method it is a simple thing to remember that free chlorine and free hydrogen sulphide cannot exist in the same solution at the same time and that, therefore, the faintest trace of free chlorine will preclude the presence of any hydrogen sulphide.

O'Connell further states that the chlorine attacks the hydrogen sulphide gas before it attacks any of the liquid or solid portions of the sewage, the reaction resulting in the production of free sulphur and hydrochloric acid.

Diagram Showing How Smoke Flag Follows Contours of the Earth and Any Intervening Obstructions

Since the production of hydrogen sulphide from sewage is dependent on the action of bacteria, it is sometimes found economical to chlorinate the incoming sewage to prevent such bacteral action instead of attacking the ready-formed gas. Decision on the point and method of attack would depend on local conditions and cannot be entered into in this article.

Odors from Digesting Sludge.—Odors from Imhoff tank digestion compartments may escape either directly from the gas vent or from the tank effluent through the return of septic material through the slots. The latter case calls for chlorination of the tank effluent. A study of the individual case will probably reveal that the undesirable conditions are confined to certain hours of the day and that chlorination to cover these hours would be sufficient. While there is considerable hydrogen sulphide in the gas escaping directly from the gas vents, under the most favorable conditions with alkaline digestion and the escape of gas unimpeded by scum, migrating odors of any magnitude should be infrequent since the uniform evolution of gas is favorable for diffusion and dispersement. Acid digestion and the choking of the vents with scum go hand in hand to make for spasmodic release of highly offensive odors upon every change in atmospheric condition.

Separate sludge digestion tanks are most easily controlled as regards odors because treatment to correct acid conditions is very readily applied and because it is equally simple to keep all solids submerged and to collect and burn all gases. Since the fuel value of the gas is high this method of odor control can be made profitable. The only precaution necessary is to see that the gas-collecting apparatus is so designed that a positive pressure will always be maintained to exclude air under any and all conditions.

Virginia Water and Sewage Works Association to Meet in Norfolk

The 2nd annual convention of the Virginia Water and Sewage Works Association will be held at the new Nansemond Hotel, Ocean View, Norfolk, Va., June 19th and 20th. The program contemplates a number of interesting papers and discussions referring to plant operation in treating the variety of raw water supplies obtained in the state; also papers and discussions dealing with impounding reservoirs and maintenance of watershed areas. The program also includes discussion of the application of advantageous methods of sewage treatment. H. W. Snidow, Assistant, State Department of Health, Richmond, Va., is Secretary-Treasurer of the Association.

The World's Largest Pumping Station

New Springwells Project of Detroit, Mich., Will Have Special Power Plant

CONSTRUCTION will be started soon on the Springwells pumping station of the city of Detroit, Mich. It is stated it will be the largest single pumping station in the world. It is expected it will be in operation in 1932.

The Detroit water supply is obtained from the Detroit River through an intake near Belle Isle. The water flows by gravity through a tunnel to a reservoir from which it is pumped by low-lift pumps into a filtration plant. The clear, purified water flows from the filters by gravity into storage reservoirs whence it is pumped directly into the mains.

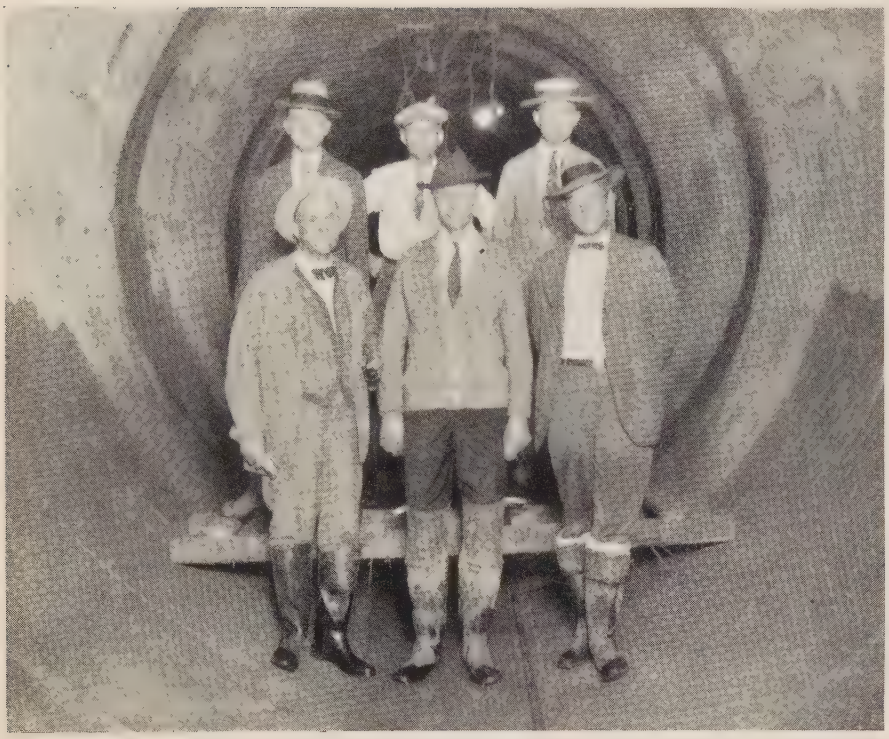
In 1925 a program was begun for increasing the capacity of the present Waterworks Park Station, and the construction of the entirely new and independent Springwells Station. Several of the obsolete steam engine driven reciprocating pumps in the older station were replaced with modern electric equipment.

The new Springwells project is located on West Warren Ave. approximately 14 miles from Waterworks Park. It will take its water from the Detroit River through a new intake at the head of Belle Isle. The water will flow by gravity through a concrete lined tunnel 14 and 12 ft. in diameter, laid along Forest and Warren Aves. and emptying into a large well 56 ft. in diameter and 100 ft. deep. Thence the water will be pumped into a filter plant. It will flow from the filter plant by gravity to the pumping station, where a series of pumps will force it directly into the mains.

All of the pumping equipment in the new station will be of the most modern design, and will be driven by electric motors built by the General Electric Co. The low lift centrifugal pumps which take the water from the large well are being manufactured by the Worthington Pump & Machinery Corporation. Six will be 750-hp. units, and two will be 350 hp. in rating. The 750-hp. pumps will be driven by synchronous motors, while the smaller pumps will be driven by slipring induction motors. There will also be two smaller pumps for dewatering the tunnel. These are to be furnished by the American Well Works and will be driven by two-speed induction motors rated 100/200 hp., 720/900 rpm. Two sump pumps, made by the same concern, will be driven by 5-hp. induction motors.

The horizontal high lift centrifugal pumps that take the water from the filter plant and pump it into the mains also are being made by the Worthington Pump & Machinery Corporation. Sixteen of these will be eventually installed, 12 of which are now being made. Four will be rated 1,725 hp. each, and will be driven by synchronous motors running at 600 rpm; two will be 1,675-hp. pumps driven by synchronous motors at a speed of 514

Construction Work on the New Pumping Station



Interior of the Tunnel

rpm., and two will be 1,425-hp. pumps driven by synchronous motors with a speed of 514 rpm. The four remaining pumps will be driven by slipring, variable-speed induction motors, two rated 1,400 hp., 713/647 rpm., and two rated 1,200 hp., 507/461 rpm.

The great size of the new pumping station and the consequent large demand for electric energy made it necessary to plan a special power plant for the Springwells project. This is designed for an ultimate capacity of 30,000 kw., consisting of two 5,000-kw. and two 7,500-kw. turbine generators, and using a 5,000-kw. transformer bank. This electric equipment will be supplied by the General Electric Co. The transformers will be used to tie in with a separate source of central station power.

Auxiliary power in the station will be furnished by three General Electric turbine generators each rated 500 kw. Steam will be extracted from the stages of the turbines and used for heating the building. Thus the steam for heating will be obtained as a by-product of the power generation process.

The land tunnel for the new project is nearly complete. The river tunnel which will connect the land tunnel with the new intake is under construction. The ventilation of this tunnel during construction is a matter of great importance because of pockets of hydrogen sulphide gas which occur in the limestone rock formations. Proper ventilation is provided by two General Electric centrifugal compressors, each supplying 9,000 cu. ft. of air per minute at a pressure of 2 lb., and driven by 120-hp. induction motors. Specially designed General Electric control and indicating equipment shows the deliverv of air from the blowers in terms of cubic feet per minute.

Third Annual Meeting of Pacific Northwest Section, A. W. W. A.

The 3rd annual meeting of the Pacific Northwest Section of the American Water Works Association was held in Portland, Ore., April 24-26, 1930. The total registration was 149.

At the banquet, which was held on April 25, the total attendance was 139. A short talk was given by Jack J. Hinman, Jr., president of the American Water Works Association, on the aims and motives of the association, and also a few remarks were made by Ben S. Morrow, chairman of the Pacific Northwest Section, and by Ernest C. Willard, secretary-treasurer.

At the banquet the golf prizes awarded in connection with the golf tournament were given the recipients, which were as follows:

First prize, golf bag—Sam W. Kerr, Mueller Company, Seattle, Wash.

Second prize, golf bag—Robert W. Martindale, Pacific Coast manager, U. S. Pipe & Foundry Company, San Francisco, Calif.

Third prize, three matched wood clubs—Ross A. Gridley, assistant division engineer, Public Works Engineering Corporation, Salem, Ore.

Fourth prize, three matched wood clubs—A. D. Mars, Jr., Neptune Meter Company, Denver, Col.

Fifth prize, one dozen golf balls—H. A. Goode, assistant to Commissioner of Public Utilities, Portland, Ore.

Sixth prize, one dozen golf balls—W. B. Severyns, superintendent Water Department, Seattle, Wash.

Seventh prize, putter and ball—James Q. Osborne, DeLaval Steam Turbine Company, Seattle, Wash.

Eighth prize, putter and ball—J. L. Hill, Pacific States Cast Iron Pipe Company, Provo, Utah.

Ninth prize, raincoat—H. D. Fowler, Pittsburgh-Des Moines Steel Company, Seattle, Wash.

Tenth prize, raincoat—David E. Wallbom, accountant, Seattle, Wash.

Eleventh prize, one-half dozen golf balls—S. J. Benedict, assistant engineer, Water Bureau, Portland, Ore.

Twelfth prize, one-half dozen golf balls—Alex Lindsay, superintendent Water Department, Spokane, Wash.

At the business session the following officers were elected:

Chairman—Alex Lindsay, superintendent Water Department, Spokane, Wash.

Vice-chairman—Carl A. McClain, general superintendent-secretary, Eugene Water Board, Eugene, Ore.

Secretary-treasurer—R. F. McLean, superintendent Water Department, Walla Walla, Wash.

Director—R. H. Corey, division engineer, Public Works Engineering Corporation, Salem, Ore.

Director (hold over)—Fred J. Sharkey, superintendent Water Department, Wenatchee, Wash.

W. A. Kunigk, superintendent Water Division, Tacoma, Wash., was elected National Director, to hold office until 1932.

Water-Works Systems in Ontario.—In the province of Ontario 308 waterworks systems are in operation and supply municipalities having a total population of over 2,000,000. This is equivalent to over 65 per cent of the total population of the province. The population of Ontario is usually regarded as being about 50 per cent rural. These systems are nearly all publicly owned and operated. It is the exception rather than the rule to find a system of any size which is not owned by the municipal corporation. These systems distribute nearly 350,000,000 gal. of water per day, the majority of which is unmetered and supplied at a very reasonable charge to the consumer.

The following table indicates the number of systems supplied from various sources:

	Total Numbers	Per Cent of Total
Wells	60	20
Springs	37	12
Lakes	81	26
Rivers, etc.	130	42
Total	308	100

The New Filtration Plant at Sheboygan, Wis.

Plant Now Under Construction Has 12-M.G.D. Capacity, Supplemented by 1,750,000-Gal. Clear-Water Reservoir—Capacity and Provision for Expansion Allow for Future Growth of City

By CHARLES B. BURDICK

Alvord, Burdick & Howson, Consulting Engineers, Chicago, Ill.

THE plant now under construction at Sheyboygan, Wis., for filtering the city water supply from Lake Michigan has a rated capacity of 12 m.g. per 24 hours.

The Sheboygan water works is situated on the lake shore in the northern part of the city and adjoins Vollrath Park. The present pumping station, built many years ago, but added to from time to time with the growth of the city, has drawn its supply by suction and pumped it into the city mains against direct pressure.

The filtration plant now under construction adjoins the pumping station upon the south and occupies the top and slope of a clay bluff rising to a maximum height of 48 ft. above the lake. A portion of the plant is built directly upon the beach and is protected by a suitable breakwater. The new plant includes a low-lift pumping installation taking water from the old intake shaft and discharging it through mixing tanks, coagulating basins and gravity mechanical filters into a clear-water reservoir occupying the space beneath the filters and with an extension forming a covered reservoir accommodated on what was the beach of Lake Michigan.

Population and Water Consumption.—The present population of Sheboygan is approximately 40,000.

During the past 15 years, the pumpage has grown from 3.3 to 5.6 m.g.d. At the present time, 47 per cent of the consumers are metered. During the past year pumping rates were as follows:

Average 24 hours	6 m.g.d.
Greatest 24 hours	9.4 m.g.d.
Peak rate—greatest hour	19 m.g.d.

The plant capacity of 12 m.g., supplemented by 1,750,000 gal. in clear-water storage, is estimated to be sufficient for present requirements and to allow for a moderate future growth.

In adding filtration to the existing pumping operations, it seemed desirable that the two should be closely coordinated so that the operations of pumping and filtering could be carried on with a minimum labor force. The plan as laid down contemplates future construction in units in order that the plant may be extended to accommodate the future growth of the city.

The plant throughout is built of fireproof construction, there being no wood about the plant except in window frames and doors. An effort has been made to build a plant of good appearance. It is believed to be a good business policy for a water board, ably and economically conducting its affairs, to have a proper regard for appearance in the structures built. The greater part of any investment is necessarily buried beneath the ground. The public is likely to judge as to its excellence by the small part of it that is visible.

Details of Plant.—The general form and dimensions of the plant are shown upon the accompanying drawings. A new breakwater consisting of a double row of piles supporting steel sheeting 20 ft. long and extending 6 ft. above the normal lake level, protects the site of the new plant. The length of shore line protected is about 40 ft. Breakwater construction is supported by anchor piles and steel rods buried beneath the terrace which adjoins the clear-water reservoir on the lake side thereof. The bottom of the clear-water reservoir is 1 ft. above normal lake level. This reservoir contains 20 ft. of water. It has vertical sides and a flat reinforced-concrete roof covered with 1 ft. of earth and sodded.

Filters are superimposed on the top of the westerly end of the clear-water reservoir. Coagulation basins and a headhouse containing chemical storage facilities and a laboratory are situated on the gradually ascending ground on the slope of the bank of the lake with only moderate depths of cutting. The different parts of the plant are thus arranged at elevations suitable to carry the water through the plant with no unnecessary head losses.

The filter-plant building is connected to the present pumping station by means of a small enclosure housing the low-lift pumps, together with an office, hallway, toilet and locker room for the use of the men in the filter building and also for the use of the men in the present pumping station. By this arrangement, it is possible to pass from any part of the pumping station to any part of the filter plant entirely within doors.

Description of Equipment.—The sizes and capacities of the various parts of the plant can perhaps best be described by starting at the present intake well and following the water throughout the plant.

Water is drawn from the present intake well through two suction pipes by the low-lift pumps, discharging under a head of approximately 50 ft. and delivering to either of two mechanical mixing tanks immediately under the entrance to the filter house. Each tank has a water capacity equivalent to 11 minutes of mixing time or 22 minutes total time at the rated capacity of the plant. The average mixing time will be about double these figures. Water will then pass from either or both these mixing tanks to either of two coagulating basins, providing a total coagulation period of three hours at the rated capacity of the plant. After coagulation, the water passes to the pipe gallery which adjoins the coagulating basin on its easterly side and thence passes to any or all of six mechanical filters each having a rated capacity of 2 m.g.d, or 12 m.g. total.

The mixing tanks, which are square in horizontal cross-section, form the cellar of the headhouse. The mechanical agitation equipment and the dry chemical feeders occupy the ground floor of the head house. Agitating equipment is water-motor operated. Coagulent storage and the plant laboratory are on the second floor of the headhouse. Chemical is brought in by truck and lifted to the storage space by elevator, and thence feeds by gravity.

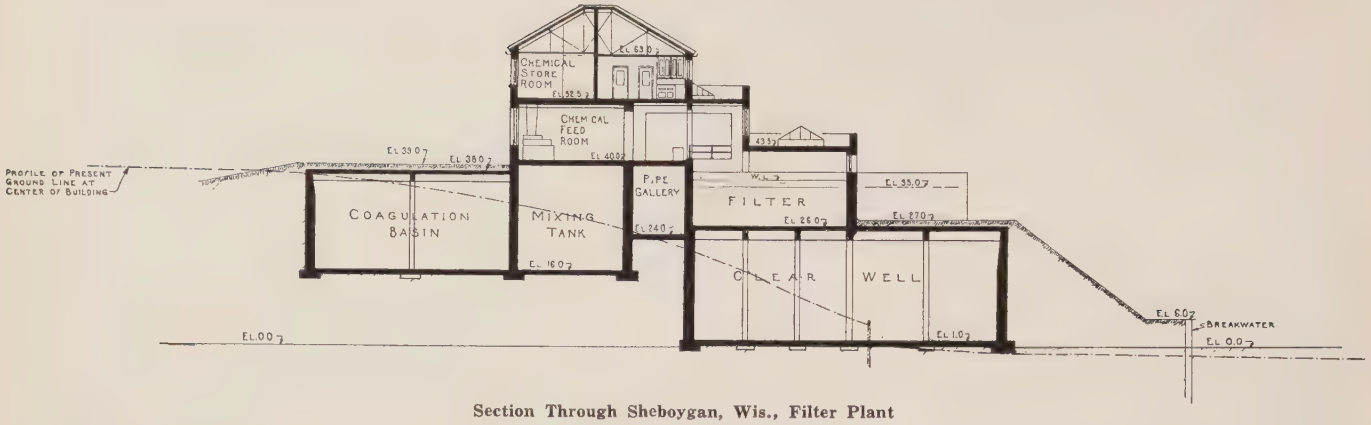
The filters are arranged in one row with the pipe gallery intervening between the filters and the coagulation basins, thus avoiding any possibility of leakage entering the clear-water reservoir. Filters, coagulating basins and clear well, together form a rectangle which can be enlarged in the future by extending each unit southward.

Filters are equipped with the usual hydraulic valves, perforated cast-iron pipe laterals, cast-iron wash troughs and the customary appurtenances of a modern filter.

Filtered water is discharged directly from each filter into a conduit suspended from the filter floors, in order to assemble all of the water at one place for chlorination as it drops into the clear-water reservoir.

Water for washing the filters is supplied from a 100,000-gal. steel tank 28 ft. in diameter and 23 ft. high set on the top of an old foundation formerly occupied by a standpipe on the southerly part of the water-works lot. This ground is sufficiently elevated to provide the necessary head for filter washing. The tank is enclosed by an attractive masonry structure also accommodated on the old standpipe foundation.

Provision is made for the aeration of the water by a fountain placed on top



Section Through Sheboygan, Wis., Filter Plant

of the coagulating basin and immediately in front of the filter house. Pipes and valves are so arranged that under ordinary circumstances the aerators will not be used.

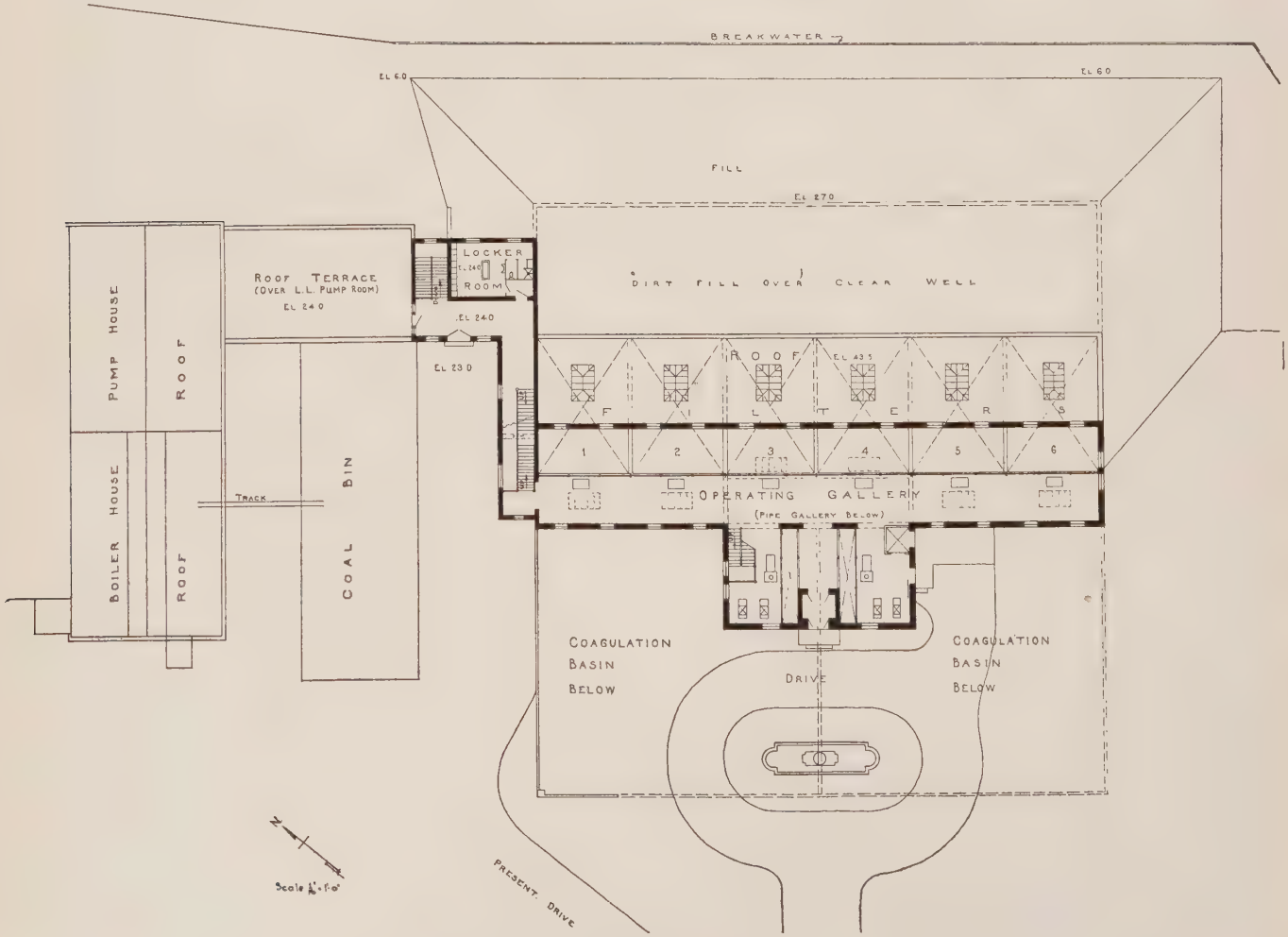
The driveway affording entrance to the plant comes in from the high ground lying shoreward directly over the top of the coagulating basins. The tops of these basins, which are sodded over, form the "front yard" of the filtration plant, so to speak. The elevation of this construction and the filter house very largely hide the old pump house which occupies low ground immediately to the north. The main entrance to the combined pumping and filter plant will be through the filter house.

This plant is being engineered in cooperation with the Jerry Donohue Engineering Co., of Sheboygan.

With the completion of this plant, another will be added to the growing number of cities that find it worth while to treat the water of Lake Michigan, thus getting a clean water all the time, and obviating excessive chlorination.

Acknowledgment.—The foregoing paper was presented at a meeting of the Illinois section of the American Water Works Association at Chicago on April 23.

Water Bills Mailed as Meters Are Read.—A change has been made in the date of mailing water bills in Brookline, Mass. Heretofore they have been mailed the first of each quarter. Hereafter, bills to be rendered will be mailed as the meters are read. By this method the consumer is at once advised of any increase in his bill, and both the billing and the accounting can be extended over a period of nearly six weeks, which is for the best interest of both the water and the treasury department.



General Plan, Sheboygan, Wis., Filter Plant

The Removal of Iron from the Water Supply of Punta Gorda, Fla.

Plant Built at Small Cost Reduces Iron Content from 19.6 to 0.1 P.P.M.—Use of City Water Doubled as a Result of Installation

By CHARLES K. DODD
City Manager, Punta Gorda, Fla.

THE water supply for the city of Punta Gorda is obtained from five 6-in. wells which are screened between depths of 60 and 90 ft., the water coming from a fine-sand stratum between these two points. These wells were put down in 1925 to replace the old deep flowing wells which were heavy in sulphur and hardness, in an attemp to get softer water and water free from sulphur. The new wells yielded a very good quality of water for several months, but continual pumping brought about a continual increase of iron and magnesia content, so that in 1929 the water contained 19.6 p.p.m. of iron and magnesia, and the water became very objectionable, both as to taste and stains resulting from its high iron content.

Punta Gorda was confronted with the necessity of doing something and of doing it at a time when its finances were very limited. It was not thought necessary at this time to attempt to soften the water, but was considered sufficient simply to remove the iron and sulphur and, if possible, do this without the use of chemicals. Experiments to this end were carried on over a period of about 18 months. It was then decided to use aeration in connection with an upward-flow contact filter. This plant was built at a very small cost and has proved very satisfactory. With it we were able to reduce the iron content from 19.6 p.p.m. down to 0.1 of 1 p.p.m.

It is a known fact that iron in solution when mixed with oxygen will form a reddish-brown precipitate of iron oxide; this precipitate has a tendency to cling to any smooth surface and, if the surface is already coated with a thin coating of iron oxide, it will cling much more readily. This principle is taken advantage of in our iron removal plant.

The well water is pumped through a 4-in. pipe to the top of a square wooden tank 5 ft. wide, 10 ft. long and 4½ ft. high. This wooden tank is filled two-thirds full of broken pieces of terra-cotta pipe, over which the raw water is distributed through 12 ½-in. holes tapped into the 4-in. pipe. The splashing of the water over the pieces of broken terra-cotta pipe is all the aeration it receives. Leading from the bottom of this open-top tank which we call the aeration tank, we have placed a 4-in. angle valve by means of which the water level in the aeration tank may be regulated. The aeration is regulated by controling the discharge with the angle valve, thereby controling the depth of submergence of the broken pieces of terra-cotta pipe. It is necessary to provide for this regulation so as to prevent excesive aeration, as excessive aeration, depending on the amount of organic matter in the water, may prevent proper functioning of the gravel filter through which the aerated water later passes.

Immediately beneath the aeration tank is another square wooden tank 5 ft. 8 in. wide, 11 ft. long and 9 ft. deep, which contains the gravel filter. The aerated water flows by gravity into an upright 8-in. open-end standpipe, the top of which is 5 ft. above the top of the lower tank, from which it is conducted to the bottom of the wooden tank just mentioned and distributed over the bottom by means of a crow-foot arrangement, consisting of one piece of 8-in. pipe, 10 ft. long, and 20 pieces of 2-in. pipe leading from this and spaced every 6 in. There are 10 ¾-in. holes spaced every 6 in. in each 2-in. pipe, and these holes face downward toward the bottom of the tank. This gives an even distribution of water all over the bottom of the tank so that the water flows upward through the upward-flow gravel filter. This filter was built out of smooth pebble gravel. The first or bottom layer is composed of gravel from 1 to 2 in. in diameter, and is 18 in. thick. The next stratum above is composed of gravel from ½ to 1 in. in diameter, and is 12 in. thick. The next stratum is gravel ¼ to ½ in. in diameter, and is 12 in. thick. The next stratum is gravel ⅛ to ¼ in. in diameter, and is 18 in. thick. The last stratum, which is the top stratum, is of gravel 1/12 to ⅛ in. in diameter and is 24 in. thick. This makes the total depth of gravel bed 7 ft., which, after the agitation caused by washing, forms an evenly-graduated gravel filter bed with coarse 2-in. gravel at the bottom, decreasing to 1/12-in. gravel at the top.

The aerated water falls by gravity into the 8-in. standpipe which conducts it into the bottom of the gravel bed, is distributed by means of the crow-foot arrangement and flows upward through the gravel bed at the rate of 2½ g.p.m. per square foot of horizontal filter area. The aeration of the water has been controlled so that the oxidation of the iron takes place and is completed while the water is passing through the gravel bed. This is necessary because it is found that if the water receives too much aeration the precipitate of iron oxide will form before the water gets to the gravel bed and a portion will pass through without clinging to the gravel. After the water passes upward through the gravel bed it is perfectly clear and is carried off to a clear well through an overflow pipe approximately 12 in. above the top of the gravel bed. From this overflow pipe the water splashes into an open wooden tank, giving it a further aeration, which removes part of the excess carbon dioxide. From this last aeration tank the water flows by gravity into a 275,000-gal. concrete reservoir, from which it is pumped into the mains.

As the gravel filter gets loaded with iron the head necessary to force the water upward through the gravel bed increases. This causes the water to stand higher in the open-end 8-in. standpipe, and when it rises high enough to overflow, the standpipe is necessary to downwash the filter. Downwashing is accomplished by opening an 8-in. valve which allows the water in the gravel bed to flow rapidly downward and out through the crow-foot arrangement in the bottom of the bed and thence to a waste pipe. In downwashing the water level in the bed is only lowered down to the surface of the gravel bed. Care should be taken not to let the water surface get below the top of the gravel bed in order to keep air from getting in. Downwashing this plant requires only about 450 gal. of water, and when running the plant continuously it is necessary to downwash once every 24 hours. When it becomes necesary to downwash more frequently than once every 24 hours (which is usually once a week) the gravel bed is upwashed.

Upwashing requires 15 g.p.m. per square foot of horizontal area of gravel bed. In our case 1,000 g.p.m. is forced upward through the crow-foot arrangement at a pressure of 75 lb. per square inch. This agitates the whole filter bed and rubs each piece of rock against its neighbor which scrapes off all the surplus iron clinging to it. The iron all boils to the top of the filter and passes out through an overflow pipe to a waste

pipe. Approximately 3,000 gal. of water are required to upwash the filter.

After upwashing the filter it is necessary to leave the waste overflow open until the water coming from the gravel bed is again clear. This usually requires from five to ten minutes, after which the clear water may be again diverted into the reservoir.

The capacity of the gravel bed described is 166 g.p.m., or 2½ g.p.m. per square foot of gravel bed. The gravel bed never needs changing; on the contrary, the longer it remains in use, the better it works. It will be noted that very little water is wasted compared to the gross amount of water passing through the plant. This plant has a capacity of approximately 230,000 g.p.d., of which less than one-half of one per cent is lost in washing processes. It requires no especial attention with the exception of downwashing once a day and upwashing approximately once a week. No chemicals are added to the water at all.

Means are provided in the piping and connections to control every phase of operation, and platforms are provided giving access to all parts of the plant for ease of inspection and operation. The plant is also constructed so that with very little expense it may be increased to twice its present capacity.

The size of a plant of this kind is limited only by the amount of water available for upwashing, since this requires 15 g.p.m. per square foot of horizontal area of gravel bed; however, any number of gravel bed units could be built, of a size limited by the volume of wash water available and arranged so that they could be washed one at a time.

The city of Punta Gorda has two 1,000-g.p.m. emergency pumps for fire protection and one of these pumps is used in upwashing our filter.

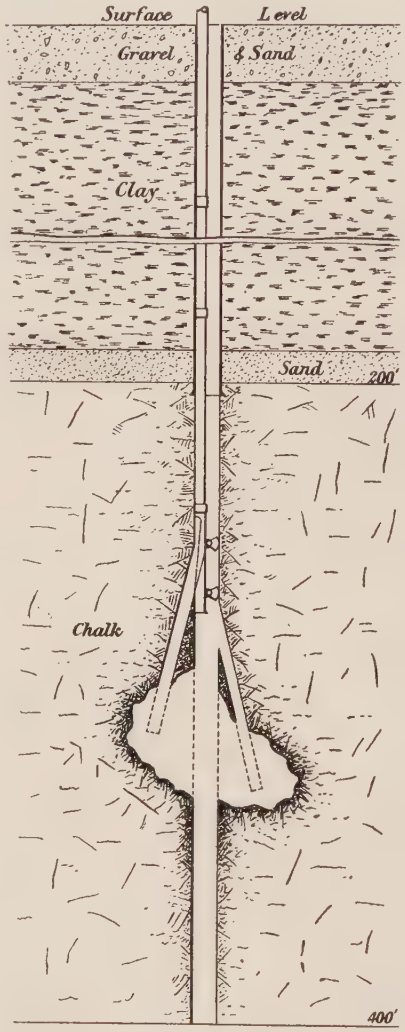
Because of the improved quality of the water, our water sales have doubled since installation of this plant, and it is estimated that the plant paid for itself in four months' time as a result of the increased use of city water. This increase is largely due to the fact that our city water may now be used for lawn sprinkling purposes, whereas the old water contained enough iron to stain grass, foliage and buildings wherever it was used for lawn sprinkling.

It is very difficult for anyone to appreciate the enormous amount of iron in a day's supply of water such as ours, without watching the effluent of the downwashing process, which appears to the eye to be just so many gallons of red barn paint.

Acknowledgment.—The foregoing paper was presented at a meeting of the Florida section of the American Water Works Association.

Blasting to Increase Supply of a Well

Explosives were successfully resorted to for enlarging a bore hole and increasing the flow of water from a well in a recent instance, according to "Engineering" (London). A 24-in. hole had been drilled to a depth of 400 ft. Upon tests, the supply of water was found to be disappointing, as barely 30,000 g.p.h. could be pumped; to obtain this yield, the level dropped to 120 ft. below the surface. The supply of water came from a chalk formation, which was reached at a depth of 200 ft. below the surface.



Section of Well Showing Deflections and Cavity

After considerable discussion of the problem, it was decided to attemp to increase the supply by blasting. The opinion was advanced that better results would be secured if the explosives were placed, not in the hole itself, but at a distance of several feet outside its circumference. In this way, it was contended, the chalk would be loosened and driven toward the hole; whereas firing of the charge within the hole might be expected to compress the surrounding strata of chalk. The cheapest method of placing such explosives appeared to be to drill deflected holes, branching off from the main hole at the proper depth below the surface. This is shown in the accompanying sketch.

A specially-designed deflecting tool was lowered into the bore hole and a 6-in. deflected hole was drilled for a distance of 60 ft., starting at a depth of 265 ft. below the surface. It was calculated that, after drilling 60 ft., the deflection had reached a deviation of about 4 ft. out of the vertical from the center-line of the bore hole. A charge of dynamite was then lowered to the bottom of the deflected hole and fired electrically. The deflecting tool was then raised 20 ft. and turned through an angle of 90 deg., and a second deflected hole was put down in a similar manner to the first, starting at 250 ft. below the surface. A charge of dynamite was now exploded in this hole. The deflector was then removed and a considerable amount of débris shelled out of the main bore hole.

The effect of the shots became apparent immediately in that the flow was more than doubled. This was considered satisfactory, and further deflections and charges were deemed unnecessary. When the well was tested subsequently it was found possible to pump approximately 76,000 g.p.h., the water level falling to only 65 ft. below the surface. In effect, a cavity had been formed equivalent to a dug well at the desired spot, where the water was most likely to be found, but at a fraction of the cost of a dug well.

Longview, Wash., Water Works Plans Expansion

The Washington Gas & Electric Co., owners of the water works system at Longview, Wash., has instructed Stevens & Koon, consulting engineers, Portland, Ore., to prepare plans and specifications for water works improvements to be built during the coming season.

The project will consist of a modern gravity-type filtration plant, an additional reservoir, a steel pumping main, an intake, pumps, motors and auxiliary equipment for a complete new water supply. The work to be done now will consist of three 1-m.g., units of a plant which may be expanded to a total capacity of 12,000,000 g. p. d. The cost of the work to be done this year will exceed $200,000.

It is expected that proposals for reservoir construction will be taken during May and for the other units of the plant as rapidly as the plans and specifications can be prepared.

Status of and Progress in Sanitary Engineering

Recent Progressive Steps in Water Purification, Sewage Treatment, Disposal of Refuse, and Air Conditioning

At the annual convention of the American Society of Civil Engineers last January, an interesting report was submitted by the committee of the sanitary engineering division of the society. The report was prepared by C. A. Emerson, Jr., chairman, H. B. Cleveland, H. F. Ferguson, J. C. Pritchard, and Robert Spurr Weston. The purpose of this report was to mention briefly certain progressive steps in the science of sanitary engineering during the past few years as applied to the purification of public water supplies, treatment of sewage, refuse disposal and air conditioning. The report, which is reprinted below from the March Proceedings of the American Society of Civil Engineers, was not intended as a complete chronicle of advancement in the above mentioned branches, nor was it an attempt to review or establish the status of the entire field.

Water Supply

During the past year or so there has been real progress in that part of the field of water supply which includes improvement in the color, odor, and taste of waters, and in devising improvements in the art of water softening.

Color Removal.—Methods for the removal of color have been greatly refined. In past years methods other than storage depended largely on the unmodified treatment of the water with sulfate of alumina, with and without the addition of alkali, and preceded in some cases by treatment with chlorine.

In many cases where the iron content of the coloring matter is high, it has recently been found that super-chlorination followed by de-chlorination will greatly facilitate subsequent coagulation with the usual chemicals. This is because the chlorine oxidizes the organic matter which, with iron, largely constitutes the color in water. Certain kinds of color are difficult to coagulate and precipitate unless oxidized by storage or super-chlorination.

Chlorine in combination with ferrous sulfate, the so-called chlorinated copperas, has been used by Hedgepeth and his associates for de-colorizing the highly colored water at Elizabeth City, N. C. This chemical used as a primary coagulant and followed by treatment with sulfate of alumina and lime effects a marked reduction in cost of chemicals, besides producing a water of superior appearance.

At the Lawrence (Mass.) Experiment Station, H. W. Clark has shown that filters loaded with ferric hydrate are efficient for removing color. The direct addition of this chemical in practice is almost unknown, although it has been used experimentally by several investigators—most recently by Edward S. Hopkins with the turbid and colored Baltimore, Md., water. It will be recognized that ferric hydrate is the coagulating chemical formed when ferrous sulfate and lime are added to a water containing oxygen; it has been used for some time at St. Louis, Mo., New Orleans, La., Cincinnati, O., and other places.

Increased economy in color removed has been effected by controlling the hydrogen-ion concentration of the treated water and by improved mixing and stirring devices. Through the use of the hydraulic jump, the Venturi throat, and impellers of pumps, chemicals are rapidly dispersed in water, and the slow velocities, so essential to the formation of well-dehydrated flocs in clear and colored waters, are procured by the use of mechanical stirrers and other basin arrangements. These modifications enable approach to the ideal decrease in velocity, roughly parabolic, between chemical application and filtration.

Filter Operation.—Progress has been made in methods for maintaining filters free from mud-balls in cases where high velocity washing at customary rates does not suffice. The use of air during washing has been of some benefit. Good results are obtained by washing the surface layers of the sand with water applied through a grid of pipes pierced with holes, and placed near the elevation of the surface of the sand when at rest.

Since 1928, a committee of the division has been considering filtering material for sewage and water treatment works, and experiments in small glass filter tubes have been conducted at various plants under the direction of James W. Armstrong, of Baltimore, Md., to determine the optimum size of sand grains and the best depth and grading of sand beds to meet the requirements of water of different types. No definite findings have resulted as yet from these experiments, but progress was noted in a paper recently presented by Paul Hansen at the convention of the Southwest Water Works Association.

Recently, Messrs. Hulbert and Hering, of Detroit, Mich., in a paper presented before the Central Water Works Association, entitled "Studies on the Washing of Rapid Filters," demonstrated that clean sand is essential to uniform and normal filter operation, and that sand may be maintained in a clean condition by washing at a rate to produce a 50 per cent or 60 per cent expansion of the sand bed. Because the viscosity of water varies with the temperature, higher rates of wash-water application are required for higher temperatures. For example, it was found at Detroit that a wash-water velocity of 30 in. per minute was required to produce a 60 per cent expansion of a given sand at a temperature of 32 deg. Fahr.; a velocity of 45 in. per minute was required to produce the same result at a temperature of 70 deg. F.

Messrs. Hulbert and Hering have shown that these high rates require little more, if any more, wash water in the aggregate; but before they can be applied, the sand must be cleaned. They use a caustic soda solution, together with washing of the sand by a ½-in. nozzle jet.

At Cleveland, O., throughout 1929 the rate of sand expansion during filter washing was maintained at approximately 50 per cent, and W. C. Lawrence reported a reduction of about 11 per cent in wash-water requirements as compared with the preivous year when filters were washed by a uniform rate of application of wash water. Due to this change in method, about 36,000,000 gal. of costly wash water were saved, and filter runs were materially increased without deterioration of the filter effluent. Maintenance of a constant rate of sand expansion during filter washing has likewise proved advantageous at the new St. Louis plant.

Odor and Taste.—Phenolic and chlorophenolic odors, due to wastes from by-product coke ovens, from gas-works, and from some wood distillation processes, have been extremely troublesome, especially in the Middle West, and new methods have been devised for their removal. Super-chlorination followed by de-chlorination is efficient in some cases, notably at Toronto, Ont., Canada, but in others it has been found of little value.

Progress has also been made by recovering the objectionable by-products at the coking plant before the wastes are discharged. The evaporation of these wastes by using them to quench the glowing coke from the ovens, which method was unsatisfactory to the manufacturer, is being supplanted by phenol recovery processes based on absorption of the phenolic bodies in scrubbers using light oil, benzene, or caustic soda. The patented Koppers process, efficient in several cases, which uses caustic soda as an absorbent, and which is said to recover from 95 to 98 per cent of the phenols, has recently been installed at Hamilton, O., at a

plant which has a daily coking capacity of 1,200 tons.

Baylis, at Chicago, Ill., and investigators abroad, have shown experimentally the efficiency and economy of activated carbon for removing odor due to excessive chlorine or to chlorophenols. By its use, waters may be over-treated with chlorine, and unpleasant tastes removed with little trouble, at an estimated cost, at Chicago, of $1.50 per 1,000,000 gal. The largest installation of activated carbon filters is the recent one at Barmen-Elberfeld, Germany.

River waters highly polluted by sewage and certain trade wastes sometimes have unpleasant odors and tastes even after treatment with chlorine and coagulating chemicals followed by filtration. These are due to by-products of decomposition. Intensive chemical treatment does not remove them, but treatment with activated carbon is effective and satisfactory.

Pre-ammoniation as a preventative of chloro-tastes as suggested by Sir Alexander Houston, of London, McAmis, of Greenville, Tenn., and others, has been successfully used by C. H. Spaulding, at Springfield, Ill., in treatment of Sangamon River water which has a high B. coli index. Treatment with ammonia prior to chlorination increased the efficiency of the latter process and prevented occurrence of tastes due to chlorine and chlorine compounds. The process is especially efficient when the water has a normal or low pH-value. The process has also been investigated extensively at Cleveland, O.

Among the large plants which have gone into service recently is the plant at Providence, R. I., where both influent and effluent are aerated, and where the mixing and coagulation processes have followed the results of recent research; also, two plants for handling hard and turbid waters at Kansas City and St. Louis, Mo.

At the two Western plants large quantities of silt have to be handled, and mechanical apparatus similar to that of sewage treatment practice has been installed for the continuous removal of the results of both plain subsidence and coagulation. The preliminary tanks, or clarifiers, at Kansas City are circular, whereas those at St. Louis are square. At St. Louis a period of 2½ hours is allowed for removing the silt by plain subsidence, after which chemicals are applied and the treated water is passed through circular mixing tanks. Then follows a 2½-hour period of coagulation in mechanically cleaned clarifiers, from which the sludge is pumped back into the preliminary subsidence clarifiers. It will be noted that, in these plants, the main improvements are the use of mechanical devices to replace cleaning by hand, and the utilization of the coagulating effect of sludge from the coagulating basin on the silt contained in the raw water.

At St. Louis, it is proposed to overtreat the water with lime and re-carbonate the lime-treated water before filtration, following the practice at plants which are concerned primarily with softening of water, such as Columbus and Newark, O., and South Pittsburgh, Pa.

Water Softening.—This oldest of purification processes has perhaps been changed the most of all during the past three years.

Through the work of C. P. Hoover and others, the Clark process, now more than 80 years old, has been improved by adding lime in excess, thereby precipitating the magnesium as hydrate and reducing the hardness of the treated water to 25 or 30 parts per million instead of the 60 or 80 parts per million that formerly obtained in municipal practice. The excess lime is removed by subsequent treatment of the causticized water with carbon dioxide gas. Carbon dioxide in concentrated solution is also used to prevent and remove accumulations of carbonates in filters, which were long a troublesome factor in the softening process.

Sodium aluminate is used in some cases in connection with the lime and soda process to provide better coagulation and removal by filtration of the chalky turbidity which results from treatment with lime and soda. Ferrous sulfate also has been used for this same purpose for several years.

Great progress has also been made in the softening of water for stationary and locomotive boilers. Here heat treatment is extensively used to complete the softening reaction, and the chemical treatment has been carefully studied and greatly improved, especially that of waters for modern high-pressure boilers.

The physical and mechanical improvements in the coagulation process which have been used so beneficially for color removal, have been found really essential in the softening process. Here, because of the great bulk of precipitate to be handled, mechanically stirred, and cleaned, re-action tanks and settling basins are rapidly coming into favor. The use of mechanical devices favors the pumping back of sludge to promote precipitation in the basin by increasing the mass of precipitate, an advantage long known to chemists, but not readily taken in practice until the introduction of these mechanical devices.

While the lime-soda process is the one most commonly used, the zeolite process, either alone or as a supplement to lime treatment, is coming into favor for municipal use. The choice between zeolite and soda treatment is determined largely by the relative costs of soda for softening and of salt for regenerating the zeolite. Zeolite without the help of lime treatment is not in favor for extremely hard waters, on account both of the high concentration of the sodium salts which would replace the equivalent calcium and magnesium salts, and of the cost of salt for regeneration.

The first large zeolite plant, that of the Ohio Valley Water Co., has been followed by one at Sewickley, Pa., in which zeolite made from glauconite (green sand) takes the place of the sand in the usual mechanical filter plant. The former of these plants has been in successful operation for more than two years; the latter is newer, but good reports are given of it. In 1928, the Village of South Orange, N. J., installed a zeolite filter, using an artificial zeolite (Doucil). This plant has been in successful operation for about a year. Artificial zeolites have the advantage of greater softening power, but cost more per pound. This additional cost, however, is often outweighed by the higher efficiency and, consequently, the smaller size and cost of the softening apparatus. Most zeolite processes are controlled by patents.

The battle against water-borne typhoid fever has been nearly won, and there are but few supplies in American cities which are unsafe from a sanitary standpoint. Many of the safe supplies, however, are disagreeable and, as standards rise, more and more attention is being given to obtaining waters which are softer and of good appearance. It is in this field that the greatest progress in the art of water purification is being made, and it is in this direction that the older processes are being improved and that more knowledge is resulting in better practices.

Steps for the development of additional sources of water supply adequate for contemplated future needs of great metropolitan areas have recently caused two noteworthy actions at law in the Eastern states to determine rights to the waters of interstate streams.

The states of New Jersey and Pennsylvania have petitioned the United States Supreme Court to prevent the City of New York from carrying out plans for the diversion of a part of the waters of the Upper Delaware River as an additional source of municipal water supply. This suit was instituted after failure of the legislatures of Pennsylvania and New Jersey to ratify tri-state compacts which had twice been proposed between these two states and the state of New York.

The other action refers to the Connecticut River and was instituted in the United States Supreme Court by the state of Connecticut against the Boston Metropolitan District Water Supply Commission to enjoin diversion of the waters of the Swift and Ware Rivers which are tributaries of the Connecticut, through the Chicopee River.

Sewage Treatment

While present-day methods of sew-

age treatment differ greatly from those of 30 years ago, progress has been gradual and, during the past few years, has consisted of modification and improvement of existing, rather than development of new, processes.

There is increasing official realization of the value of co-operative action by adjoining municipalities forming a natural drainage district for the solution of sewerage and sewage treatment problems, and of the importance of uniform and concerted action on the part of neighboring states, comprising the watersheds of great rivers, for control of the general stream-pollution problem. This is evidenced by legislation in various states during the past few years and the subsequent formation of several district or county sewerage commissions, as well as by the agreements entered into by the health officials of the states bordering upon the Delaware and Ohio Rivers and upon the Great Lakes.

There has been an increase in volume of research work and a growing tendency to place sewage treatment works under the supervision of technically trained operators provided with suitably equipped laboratories. Although the number of sewage treatment works is increasing annually, disposal by dilution continues as the prevailing method for the majority of American cities.

While protection of the public health is the major incentive for sewage treatment, there is a growing sentiment for maintenance of streams and other bodies of water in a sufficiently clean condition for recreational purposes, propagation of fish life, and parkway or residential development of the shores. The demand is not only that waters shall be inoffensive to smell, but that they shall be reasonably free from the discoloration and oily sleek of industrial wastes.

The efforts of designers and research workers are still directed toward more intensive methods of treatment, increased protection against offensive odors, and reduction of operating costs. The adoption of recently developed pumps for unscreened sewage, and semi-automatic power equipment to replace hand labor, or manually controlled equipment for various operations at treatment works, is quite common and should tend to an increase in general plant efficiency by the maintenance of more uniform conditions.

Preliminary Treatment.—In a majority of recent designs, particular attention has been given to preparation of the sewage prior to its entry into the sedimentation tanks, by removal of grit and floating solids which are not readily susceptible to digestion, or unusually productive of offensive odors during digestion. Skimming arrangements are often provided for the removal of grease, which has been increasingly bothersome during recent years. At Akron, O., preliminary treatment is provided in short-period detritus tanks equipped with grease skimmers and power-driven sludge scrapers. Fresh sludge is withdrawn to a volume of about 20 per cent of the sewage flow and, after passing through mechanically cleaned grit chambers and fine slotted screens, is returned to the inlet channel of the main sedimentation tanks. Another method is illustrated at Middletown, N. Y., where the entire sewage flow is passed through an automatically cleaned grit sedimentation and washing chamber followed by a mechanically cleaned bar screen having ½-in. clear openings. The skimming of grease is postponed until the sewage reaches the main sedimentation tanks.

Sedimentation Tanks.—Imhoff tanks are still in favor in locations where the necessarily deep excavations are not too expensive. Collection and burning of the gases of digestion for assistance in odor control is practiced to some degree in several places. The plant at New Castle, Pa., is designed for the collection of all the gas and has functioned with reasonable success. During 1929 daily gas production has been estimated at an average of approximately 0.4 cu. ft. per capita, and during the winter months it is used to heat the plant buildings.

Several installation of single-story plain sedimentation tanks with automatic power-driven sludge scrapers and removers of various designs have been placed in service and are operating successfully. A desirable feature of these installations is the prompt withdrawal of material settled from the sewage, which is advantageous both from the standpoint of digestion of the solids and avoidance of occasional deterioration of the effluent due to gas-filled masses. The theoretical sedimentation capacity in these installations range from about 30 minutes to 2 hours, depending largely on whether the units are preparatory to activated sludge treatment or for the removal of practically all readily settleable solids.

Sludge Digestion.—Fresh sludge is being treated successfully in separate sludge digestion tanks. That the period required for digestion of sludge may be materially shortened by the provision of fixed or floating covers for digestion tanks and that the gases thus collected may be used to heat water circulated in coils in the tanks to maintain temperatures favorable for the continuance of bacterial activity during winter seasons, together with control of the reaction by addition of lime, has been demonstrated at Antigo, Wis., Plainfield, N. J., and elsewhere. It is probable that forthcoming designs will provide for less than the present generally adopted storage allowance of 2 cu. ft. per capita.

Sludge Drying.—Glass superstructures of the greenhouse type for sludge-drying beds have been found to increase the number of applications of wet sludge possible throughout a year. The efficiency of these structures is dependent to a large extent on the proper direction of air currents over the surface of the sludge; and the arrangement of ventilating devices is now receiving the increased attention of designers.

Direct incineration of fresh sludge from settling tanks; de-watering of sludge from various types of settling tanks by continuously operated vacuum filters similar in principle to those in service at Milwaukee, Wis., Houston, Tex., and other places, for excess activated sludge; digestion of sewage screenings; shortening of the sludge digestion period by the maintenance of relatively high temperatures in digestion tanks; and several other associated problems have been investigated in laboratories and studied experimentally with promising results; as yet, however, they have not been confirmed by the continuous operation of full-sized plant units.

With the exception of the Milwaukee installation for the manufacture of high-grade commercial fertilizer, the disposal of dried sludge is by incineration, burial, use on the land, or similar methods which have been in effect for many years. Sludge disposal still remains a problem.

Chlorination.—Chlorination in combination with tank treatment has recently met with considerable favor either for reduction in bacterial content of the effluent or for prevention and control of odors about the works or in the body of water receiving the effluent. The action of chlorine in the oxidation of volatile products of sewage decomposition has received much study. Some recent designs have provided for the application of the chlorine at the inlet or at a point part way through the sedimentation tanks, thus avoiding the cost of separate contact chambers at the outlet.

Oxidizing Devices.—Trickling filters and activated sludge treatment are the generally accepted methods for the oxidation of sedimentation tank effluents. The continuing popularity of trickling filters is apparently due to their relatively low maintenance costs and to their record of freedom from serious operating difficulties in continuous service for 20 years or more.

Recent installations of relatively small activated sludge plants are producing satisfactory results, and are receiving increasing attention by designing engineers. For the large installations where high land values and the necessity for freedom from nuisance conditions are matters of major importance, the trend is toward activated sludge treatment. This is indicated by the selection of the process for the recently completed North Side Treatment Works, in Chicago, having a capacity of 175,000,000 gal. daily, and for the Wards Island Plant, which will

serve parts of the Boroughs of Manhattan and The Bronx in New York City, having a dry-weather flow capacity of 180,000,000 gal. daily. In both instances, automatically cleaned sedimentation tanks were adopted for preliminary treatment. At Chicago, the excess sludge will be pumped about 17 miles to the West Side sewage treatment works for digestion in Imhoff tanks; at New York it will be transported to sea after the removal of excess liquid by decantation.

Mechanical aerators for the agitation of the sewage are receiving increased consideration in smaller activated sludge plants, but in larger installations a preference for blowers and porous bottom plates continues.

Refuse Disposal

At present, the preference in the choice of the method of final disposal of municipal refuse is in favor of incineration. This is viewed as sanitary, as most economical, where long hauls are required to proper sites for reduction plants, and as offering a method for combined disposal of garbage and rubbish in one operation.

During the past few years some advance has been made in the consideration of refuse collection and disposal problems on an independent engineering basis, providing for free and open competition under carefully prepared detailed specifications, guaranties, and general plans, particularly as applying to the larger cities.

As concerns installations for the smaller cities, there still is a noticeable absence of adequate engineering service in connection with such important features as plant location and arrangement; economy in regard to provisions for present and future capacity; handling of materials; correlation of collection and transportation problems with plant location and design; and costs of construction and annual operation.

A number of relatively large rubbish incinerators have been installed recently in Philadelphia and in other large cities. Frequently, these installations include bailing presses, sorting belts, and other equipment to facilitate salvaging of salable refuse. The wastes as received ordinarily do not contain as high percentages of garbage as those in cities where mixed collection systems are maintained. However, the design of firing and combustion chambers is generally such that, where necessary, an increased percentage of organic matter can be burned without nuisance.

As a culmination of long-standing complaints by New Jersey municipalities against the dumping at sea of garbage and refuse from New York City, the state of New Jersey received permission during 1929 from the United States Supreme Court to sue the state of New York for water pollution and shore littering. Hearings in the case before a special master have been started.

Recent Installations.—Some recent installations have included specially designed ash-handling equipment; provision for the ventilation of ash tunnels and stoking floors; facilities for the ready cleansing of working spaces, storage bins, and equipment; and similar betterments which tend to improve labor and general plant conditions.

A few large refuse incinerators were completed or under construction during the year, including three plants in Brooklyn, N. Y., each with a capacity of 500 tons per 24 hours; one at Montreal, Que., 300 tons; at Atlantic City, N. J., 240 tons; at Yonkers, N. Y., 200 tons; at Ashbury Park, N. J., 180 tons; and one at Racine, Wis., 120 tons. A small 50-ton plant was constructed at the transfer yards of the Pennsylvania R. R. in Pittsburgh, to dispose of waste vegetables and fruit. In addition, there have been more than 30 smaller installations, with rated capacities, ranging from 25 to 100 tons.

Four new refuse incinerators are proposed or under construction in the Boroughs of Manhattan and The Bronx, New York City. It is believed that the recent establishment by charter amendment of a sanitation commission to have charge of sewage treatment, refuse disposal, and street cleaning throughout the city, will speed the program for incinerator construction.

At San Francisco, Calif., a proposal to construct a new refuse incinerator was approved in the November, 1929, election, but the record of indecision in refuse disposal matters evidenced in that city in the past has again been emphasized by the defeat of two opposing supplementary propositions, one for public and the other for private ownership and operation of the incinerator.

Air Conditioning

In recent years added impetus has been given to the technical study of air conditioning through the efforts of several scientific organizations.

The study of ventilation may be said to date from the work of Lavoisier during the last quarter of the Eighteenth Century on the chemical nature of air. In 1862-63 von Pottenkofer published the results of studies of the composition of air and a discussion of th effects of carbon dioxide, of the decrease of oxygen, and of alterations of temperature and humidity on the well-being of persons.

It was not until 1902 that specific laws were enacted in Massachusetts to govern ventilation in school houses and public buildings. Similar legislation was adopted in New Jersey in 1903, and in New York in 1904. By 1925 laws or regulations covering ventilation in schools were in force in 31 states.

Important contributions to knowledge in this particular science have been made by the Chicago Commission on Ventilation which reported in 1914, and by the New York State Commission on Ventilation which was appointed in 1913 and reported in 1923.

For crowded places, such as large theatres and convention halls, it is generally recognized as necessary that there be a carefully planned mechanical distribution of fresh air of adequate volume, without the production of undesirable chilling drafts or the accumulation of overheated air in secluded spots. It is also recognized that in residences, or less crowded places, adequate ventilation can be secured through open windows, There is, however, a decided difference of opinion as to the relative value of open window or gravity ventilation and of forced or mechanical ventilation as applied to school-rooms, offices and other places of moderate occupancy.

In general, public health officials through the medium of the American Public Health Association have advocated the open-window gravity system, whereas the proponents of mechanical ventilation have been represented by the American Society of Heating and Ventilating Engineers.

The toxic properties of industrial gases are receiving the attention of investigators. Especially noteworthy is the interest manifested by the U. S. Bureau of Mines in the problem of mine ventilation, which was responsible for the construction of a research laboratory near Pittsburgh, now being operated jointly by this Bureau and the American Society of Heating and Ventilating Engineers.

Respecting progress during 1929, the outstanding event was the design and installation of an elaborate and efficient ventilating system for the Houses of Congress, under the advice and approval of a special committee appointed by the U. S. Public Health Service.

Miscellaneous

Space does not permit comment on advanced methods for the protection of the milk supply, smoke abatement, shellfish protection, mosquito eradication, rat-proofing, and the like, except to record a growing realization on the part of municipal, state and government officials that certain phases of these problems properly come within the province of the sanitary engineer.

Cement Storage Bins Have Air Jets

At the central mixing plant of the Super Concrete Corp., Washington, D. C., bulk cement is delivered in dump trucks and carried by a bucket elevator to an overhead bin. Air jets are used to break up any consolidation of the cement which might occur under the pressure of the material above; thus, whenever the discharge gate is opened, the cement flows freely down to the batcher. The jets are placed at close intervals on the side walls. The air is controlled by a throttle valve.

Water Works and Sewerage

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The Cause of the Freak Weather of 1929

One of the 11.2-year sunspot "peaks" was due about Nov. 1, 1928. These particular "peaks," as the editor has shown, are caused by the pointing of Jupiter's magnetic axis more nearly toward the sun once in 5.6 years. When the north pole of that axis points most nearly sunward very many sunspots are generated, unless the magnetic field of some other planet diverts Jupiter's lines of force. For a year or two on each side of a Jupiter "peak" the sunspots are very numerous, showing that Jupiter's magnetic "beam" is not narrow. When either the north or south pole of this magnetic beam points most nearly earthward, our weather is greatly disturbed. The sunspots (being themselves electromagnets) aid in this disturbance.

The mechanism by which weather is thus affected is, briefly, this: Electrons in the earth and the air rotate around lines of magnetic force. When thus rotating they become electromagnets. As magnets they are attracted or repelled by other electromagnets. There results a flow or migration of electrons in the earth and its atmosphere with every change of magnetic force, whether due to the magnetic fields of the sun, of sunspots or of planets. There are 12 great permanent electron whirls on the earth, 3 around the arctic circle, 3 around the antarctic circle, and 6 around the equator in tropical and subtropical regions. When electrons flow into any of these 12 regions, these electron whirl-belts increase in intensity and their radii expand. Each whirl-belt ascends as a cyclone, bends over and descends as an anticyclone. In the regions of these 12 permanent cyclones and their anticyclones, small migrating cyclones are generated. These migrating cyclones cause all our storms. Such a cyclone may be very large, 1,000 miles or more in diameter, and long lived, or it may be merely a "dust devil" of a few minutes' duration. Air molecules, it should be stated, adhere to electrons and are thus given rotation by the electrons.

Not only has the Jupiter magnetic axis been pointing much more directly earthward than usual, but the magnetic axis of Neptune has been pointing more nearly earthward. Neptune's magnetic north pole will be pointing most nearly toward the earth about 10 years hence. It last pointed most nearly earthward in 1778. During the decade that preceded that year, and during the decade that followed it, the weather was frequently disturbed greatly. The winter of 1784, for example, was a record breaker for severity. On July 13, 1778, a hail-storm of unsurpassed violence swept Europe. It is said to have been "the most terrific storm of the sort in weather history." On July 5, 1929, a hail-storm passed over central Europe, and its violence was second only to that of 1778. On July 18, 1929, a Colorado cloudburst wrecked the Rocky Mountain limited. During the summer and early fall exceptionally heavy thunderstorms were prevalent in western Texas, Arizona, New Mexico and Colorado; whereas at many points in the Mississippi Valley July was the third driest July in a century, and Great Britain was also parched. The West Indian permanent anticyclone, that originates as a cyclone over Africa, had migrated farther west, leaving the Mississippi dry and bringing heavy rains to Arizona, etc. Similarly the permanent anticyclone that hovers over the eastern part of the Atlantic (originating as the permanent cyclone near Iceland) had migrated farther south, and had left Britain dry while bringing storms to central Europe. In this connection it may be added that the six permanent cyclones near the arctic and antarctic circles descend as anticyclones in the tropics; whereas the six permanent tropical cyclones descend as anticyclones far to the west and but slightly changed in latitude. The reason for this difference in direction of trend of these permanent whirls appears to be this: The six arctic and antarctic whirls are almost entirely controlled by the earth's lower magnetic field whose electrons wave eastwardly, whereas the six tropical whirls rise so high that they come under the influence of the upper magnetic field whose electrons are moving westwardly.

That there are two great magnetic fields was first perceived by the astronomer Halley nearly 250 years ago. He thought that both of these fields were inside the earth, whereas one of them is above the earth, constituting what is known as the Heaviside layer of electrons. It is this upper field that enables the earth to cause a sunspot cycle of 10.76 months, which reaches its maximum effect every 26 years when its axis is most inclined toward the sun. One of these superpeaks was due Jan. 18, 1916, and another 26 years earlier, in 1890. Excessively great rainfall occurred within one month of those two months in many localities. For example, in December, 1889, the rainfall records of Los Angeles, San Bernardino and San Diego, Calif., were broken, and have been excelled only once since then; and in the case of San Bernardino the record-breaking rainfall was in January, 1916, exactly when an earth "superpeak" was due. Los Angeles experienced its second heaviest rainfall in that month.

It is not the sunspots caused by the earth that react, producing great rainfall; but the rainfall is due to the

great electron migration on the earth that results from the excessive sunward inclination of the magnetic axis of its upper field. The sun's axis and the earth's are in the same plane about Jan. 8, at which time electron migration northward is most pronounced; six months later the electron migration southward is most pronounced, due to a reversal of the polar positions.

Based upon the electron theory, we may predict that the northern winters of 1933 and 1939 will be the severest that have been experienced in many years. Rainfall in 1939, when the effect of Neptune's magnetic axis is greatest, will probably exceed that of any year during the preceding two generations, with corresponding severity of winter weather in northern localities. Likewise earthquakes and volcanic activity will be very pronounced in those two years, for the same magnetic forces that disturb the air also disturb the molten interior of the globe. Although this last statement may sound fantastic, the editor has compiled so much statistical evidence relative to crustal movements that no doubt remains in his mind that "earthquake weather" is an expression full of truth, because the air movements that determine weather are caused by the very same electromagnetic forces that produce movements of the fluid interior of the globe. Serious doubts as to the fluidity of the inner earth have been expressed by geologists in recent years, but the doubts are based on theories that are probably of no validity where enormous pressures exist.

Weather problems are complicated by the fact that the positions of the magnetic axes of at least 8 planets must be considered, and by the additional fact that each of these planets appears to have magnetic cyclonic whirl centers like the 12 that exist on the earth. Fortunately these whirl centers on the planets appear to be symmetrically arranged. At any rate, the editor has found that Jupiter causes stormy periods not merely when its magnetic poles point most nearly earthward every 5.6 years, but at intervals indicating the existence of 12 magnetic centers, 6 of which are powerful. Similarly certain other planets, notably Uranus, produce rainfall cycles that indicate the existence of several magnetic centers equally spaced in longitude.

The earth is much more delicately susceptible to electron migration than is the sun, and its stormy periods are brief compared with those on the sun. Yet there is a strong similarity between cyclonic activity on the earth and on the sun, each phenomenon serving to throw light on the nature of the other. Here, as so often has happened in science, true theories have originated from the contemplation of two classes of phenomena that seem at first to be unrelated. The meteorologist who confines his researches to gas movements on the earth has little chance of understanding much about weather. The earth's gases (mainly air) resemble the sun's in being electrified and in motion as currents. The greater electrification of solar gases gives them more violent motions on a scale so large that we can learn much about such motions. Just as study of the motions of the heavenly bodies taught men a vast deal about mechanics, so does study of the motions of the sun's atmosphere cast a flood of light upon the mechanism of the earth's atmosphere.

It has been said that the editor of an engineering magazine should not attempt to discuss astronomical phenomena. But such critics forget (if ever they knew) that "the philosopher arrives at an intimate persuasion of one indissoluble chain of affinity binding together all nature."

Cosmic Rays and Gravitation

Robert A. Millikan, Nobel prize winner and director of the California Institute of Technology, has discovered very penetrative radiations that he calls cosmic rays because they come from all directions. They have been found to penetrate 700 ft. into the earth, and are the most penetrative of all radiations yet discovered.

Because these rays show no particular origin, such as a star or group of stars, Dr. Millikan has suggested that they may be generated during the evolution of atoms everywhere in "the vost cold reaches" of interstellar space. While this is an ingenious and fascinating hypothesis, may not a more probable one be derived from the Einstein theory of "curved space"? Einstein's theory of relativity leads him to predict that light travels in curved paths, and that the universe is a "closed universe" from which no radiations can escape. The gravitative pull of all energy is shown by him to be capable of preventing any radiations from escaping from a spherical universe and Dr. Ludwik Silberstein has recently estimated that the diameter of this universe is about 9,000,000 light years.

Just two years ago Dr. C. J. Davisson, of the research staff of the American Telephone and Telegraph Co., announced that he had succeeded in disintegrating electrons. Such disintegrations would probably produce radiations of very short wave length, and since they can not escape from our universe they must be traveling in all directions through it. The same would hold true of radiations resulting either from the disintegration or integration of atoms. But whatever the source of the very short Millikan waves, the Einstein theory leads, we think, to the inference that space must be literally full of them, and that they must be moving in all directions. The main source of the Millikan rays is probably the stars, even though such rays come from every direction in space. It is noteworthy that only the simplest of all atoms, hydrogen, is found in all stars.

If, as seems probable, gravitation and electric attraction are first cousins, then gravitation is probably due to radiant waves that are emitted by all matter. Such waves must be much more penetrative than the Millikan rays. The editor has previously advanced the following hypothesis to explain gravitation: Radiant rays emitted by particle A strike particle B and cause more radiant rays to escape from the far face of B than from its near face. The reactive push of this unbalanced emission of rays from B would tend to impel it toward A. Similarly A would be so acted upon by B as to tend to move toward B. The Newtonian law of gravitation is readily deduced from this hypothesis. Moreover there is an abundance of laboratory evidence that an unbalanced escape of radiations (such as the hypothesis assumes) actually occurs under certain conditions.

H. P. Gillette

WATER WORKS CONVENTION ISSUE

WATER & WORKS SEWERAGE

Design ~ Construction ~ Collection
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June, 1930 — H. P. Gillette Editor — Vol. LXXVII. No. 6

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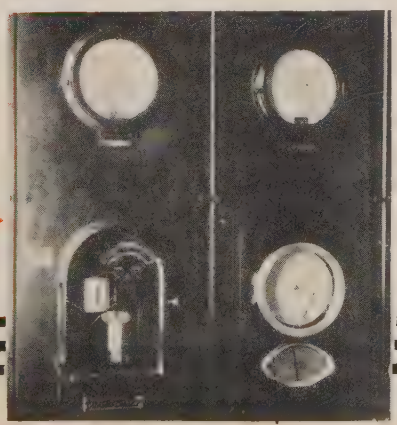

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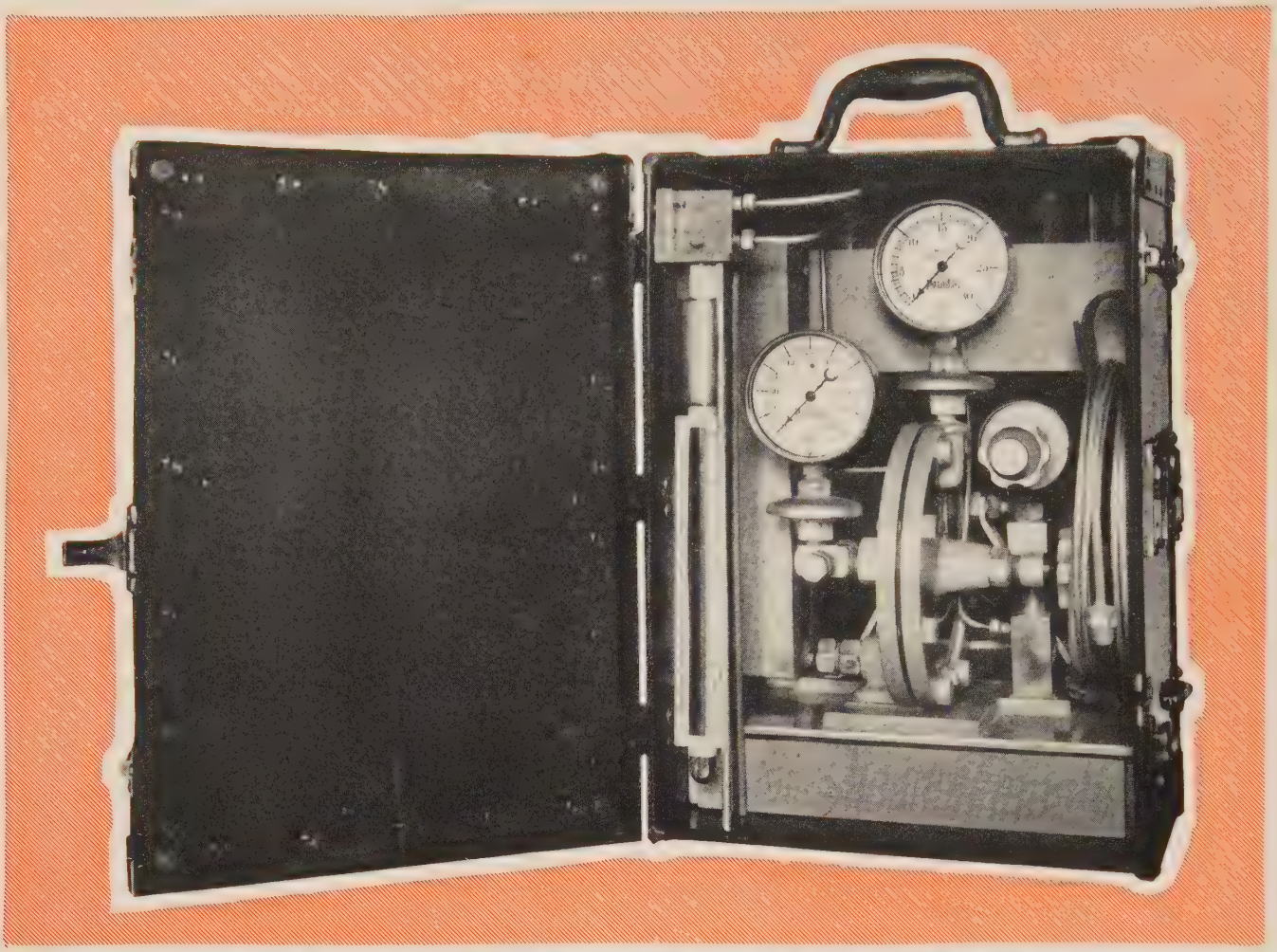

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H. P. GILLETTE, Editor

Vol. LXIX JUNE, 1930 No. 6

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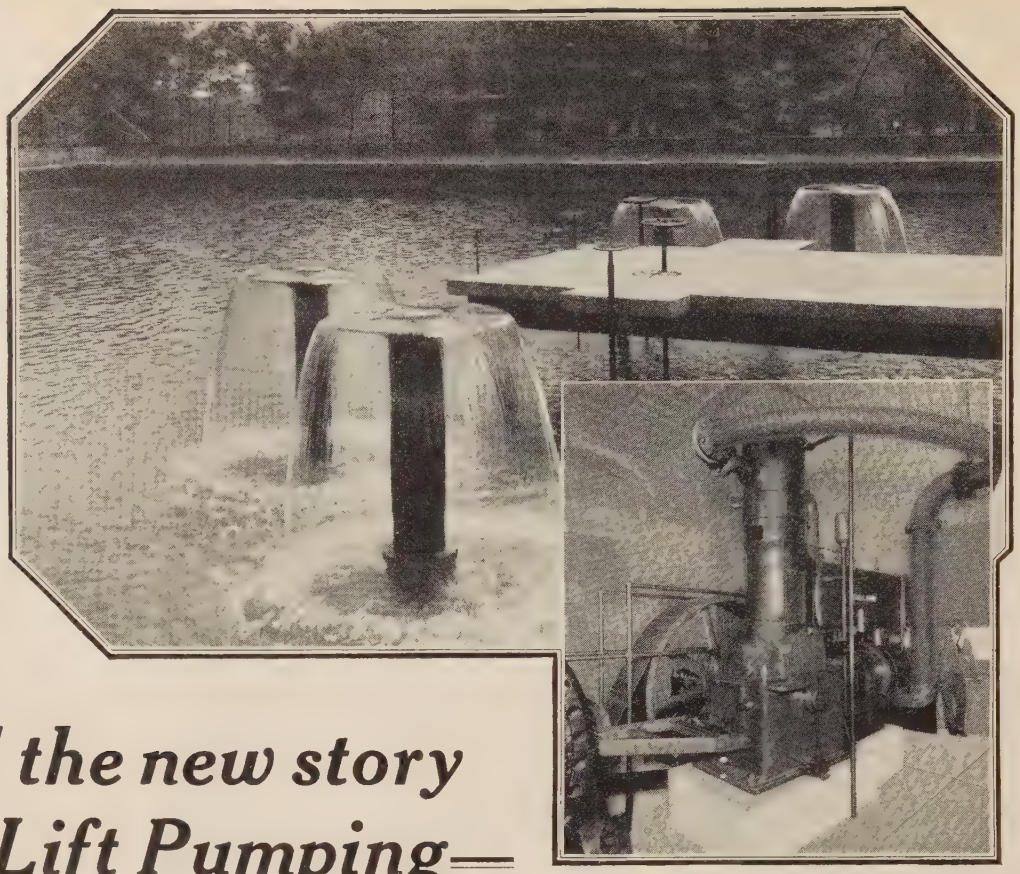

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Water Works and Sewerage

Vol. LXXVII JUNE, 1930 No. 6

The Bissell Point Station of the St. Louis Water Works

The Water Works of St. Louis, Mo.

City Has Two Independent Sources of Supply and Two Separate and Interconnecting Distribution Systems

ST. LOUIS obtains its water from the Mississippi and Missouri Rivers by means of two independent sources of supply and two separate and interconnecting systems of distribution.

The sources of supply are named after their respective locations on the two rivers—"Chain of Rocks" on the Mississippi and "Howard Bend" on the Missouri. The two distribution systems are named after their respective reservoirs—"Compton Hill" and "Stacy Park."

Each source of supply has complete low pressure pumping and purification plants. Howard Bend Station, in addition, has its own high pressure pumping plant, but this function is performed for the Chain of Rocks Station by the high pressure stations located at Baden and Bissell's Point, a distance of 4 miles and 7¾ miles, respectively, from the Chain of Rocks.

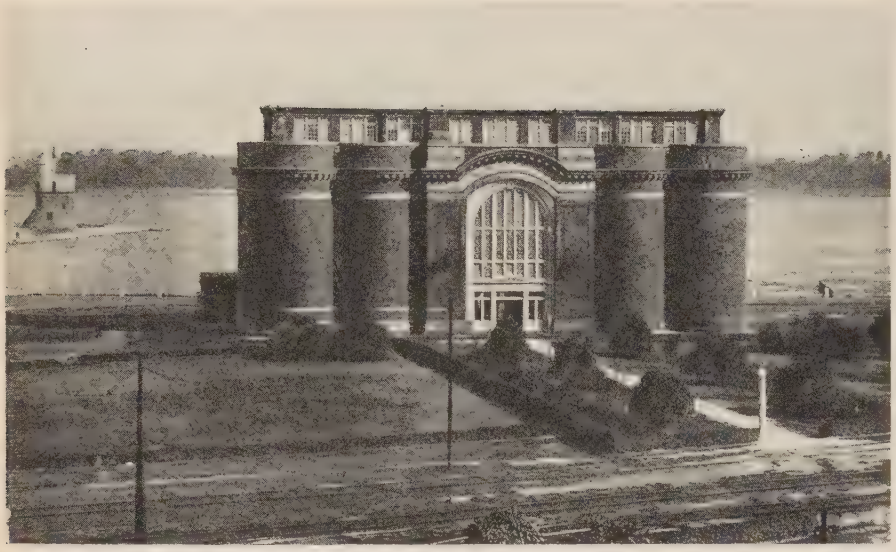
The Compton Hill distribution system serves the lower parts of the city, lying mostly east of Grand Boulevard, and is supplied by the Bissell's Point Station.

The Stacy Park distribution system serves the high districts lying mostly west of Grand Boulevard, and is supplied by the Howard Bend and Baden Stations.

These systems are interconnecting so that the Stacy Park system can be made to supply the Compton Hill system if necessary.

The Chain of Rocks Station is complete as far as capacity is concerned. Any future increase occasioned by growing demand will be supplied by the Howard Bend Station, which is so designed and constructed that additional units for increasing the capacity may be added to any part of the plant without interfering with its operation.

Chain of Rocks Station.—At the Chain of Rocks Station the muddy river water is drawn from the Mississippi River through one or more of three intake towers, two of which are located in the channel and one at the shore. From these intakes the water passes through tunnels in solid rock under the river to the wet well, from which it is drawn by the low pressure pumps. The low pressure pumps raise the water an average of 40 ft. to the delivery well. From this point it flows entirely by gravity through the remainder of the



Chain of Rocks Coagulant House

plant and to the storage basins at Baden and Bissell's Point Stations, a distance of 4 miles and 7¾ miles, respectively.

From the delivery well the water passes through the grit chamber where sand and heavy sediment is removed, then to the lime mixing conduit, at the entrance to which milk of lime prepared in the coagulant house is added. The purpose of the conduit is to thoroughly mix the lime with the raw water, this being accomplished by a travel of 1⅔ miles through this channel.

Upon leaving the mixing conduit and before entering the primary settling basins through the filling conduit, a solution of sulfate of iron, also prepared in the coagulant house, is added. The water is then allowed to remain in the primary settling basins an average time of 34 hours, after which the settled water passes by means of the collecting conduit through two venturi meters into a secondary coagulation basin. At this point a solution of sulfate of alumina is added and also a preliminary dose of chlorine applied.

From the secondary coagulation basin the water flows through two secondary settling basins and then through the rapid sand filters to the drawing conduit chamber. Here it is again sterilized with chlorine before entering the delivery conduits which conduct it to the high pressure pumping stations at Baden and Bissell's Point.

At the Baden Station, four miles south of the Chain of Rocks Station, part of the water enters a covered storage reservoir, from which it is taken by the pumps and delivered into the Stacy Park distributing system. The two main delivery conduits continue on 3¾ miles to Bissell's Point Station, where the balance of the water enters the covered storage reservoirs, from which it is pumped into the Compton Hill distribution system.

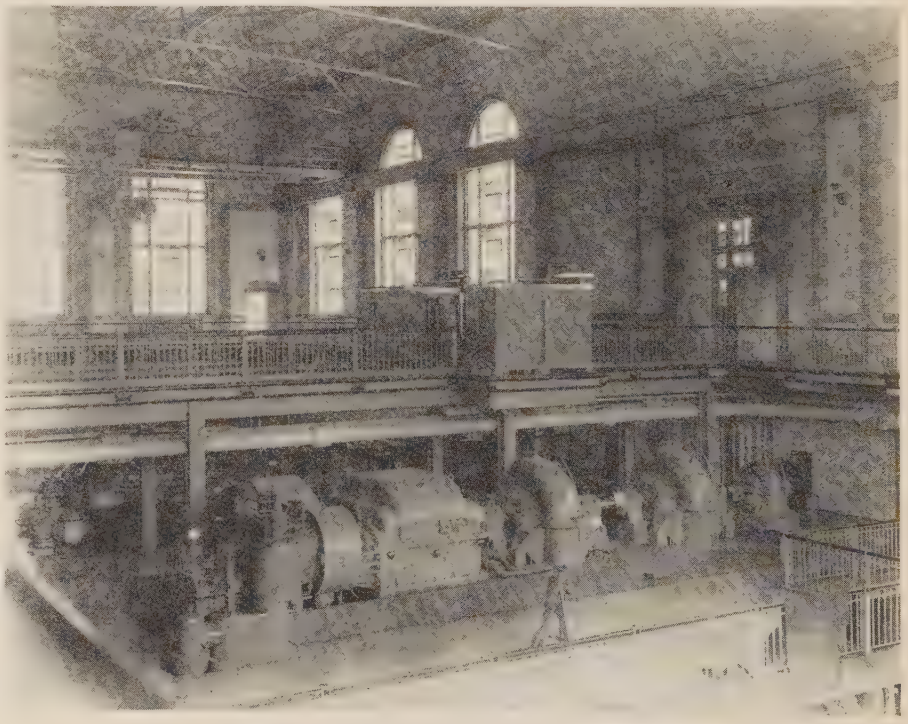
The pumping equipment at the Chain of Rocks Station consists of four Allis-Chalmers vertical compound engines, each having a capacity of 35,000,000 gal. per 24 hours and three DeLaval steam turbine-driven centrifugal pumps, two having a capacity of 35,000,000 gal. and one a capacity of 110,000,000 gal. per 24 hours.

East Intake Tower, Chain of Rocks

The Baden Station is equipped with six Allis-Chalmers triple expansion high duty pumps having a total capacity of 80,000,000 gal. per 24 hours.

The Bissell's Point Station pumping equipment consists of three Allis-Chalmers and three Holly vertical triple expansion high duty pumps, and one Cameron steam turbine-driven two-stage centrifugal pump, each with a capacity of 20,000,000 gal. per 24 hours, giving the station a combined pumping capacity of 140,000,000 gal. per 24 hours.

Howard Bend Station.—The Howard Bend Station recently completed at a cost of $12,000,000, provided from bond issue funds, is at present a complete system, producing and delivering to the city mains each day, 55,000,000 gal. of pure drinking water. It comprises a shore intake, equipped with traveling screens, and standing just off the deep channel of the Missouri River, the channel having been brought into its present location, and confined there, by an elaborate system of hurdle dikes and revetment work; a low service pump pit and house built integral with the intake; a high pressure pump pit and house, the house adjoining the low pressure house and the pits connected by a tunnel; a boiler house connected by an inclined belt conveyor to a coal receiving and crushing station; a chimney 275 ft. high, housing in its base



Howard Bend High Pressure Pumps

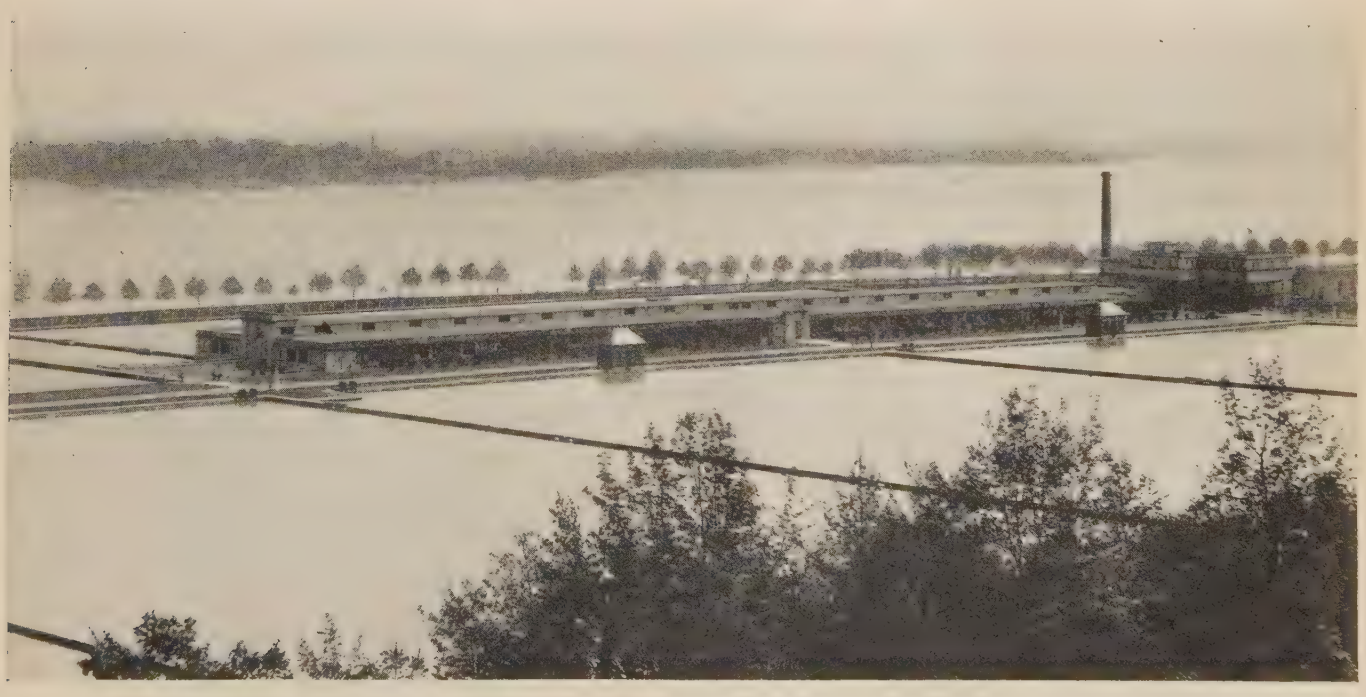
Howard Bend Filter Plant

a carbon-dioxide plant; four settling basins, each 150 ft. square, provided with mechanical scrapers for continuously removing the accumulating sludge; two sludge pump houses; a coagulant house equipped with pneumatic equipment for unloading and conveying chemicals and for the storage of chemicals and their preparation for admixture with the water; mixing conduits and reaction chambers; two large sedimentation basins; a carbonating chamber; filter plant; head house and chemical laboratory; covered clear water basin; and the 100,000,000 gal. covered storage reservoir at Stacy Park, with 16.4 miles of 62-in. steel pipe line to convey the purified water from the high pressure pumps to it and thence to the city mains.

At the Howard Bend Station the raw water is drawn from the Missouri River through the shore intake and passes through vertical traveling refuse screens that remove all sticks, leaves, etc., before passing to the low pressure pumps which raise the water into the rising well, an average lift of 33 ft. From this point the flow through the purification system to the high pressure pumps is entirely by gravity.

West Intake Tower, Chain of Rocks

From the rising well the water flows to two preliminary sedimentation basins where 50 to 95 per cent of the suspended mud and sand are removed by natural sedimentation. These basins are equipped with revolving scrapers for the continuous removal of the deposited mud and sand. The water then flows through a rapid mixing conduit where milk of lime, prepared in the coagulant house, is added and thoroughly mixed with the water before it passes into four circular reaction chambers where sulfate of iron, also prepared in the coagulant house, is added. Thirty



Chain of Rocks Filter Plant

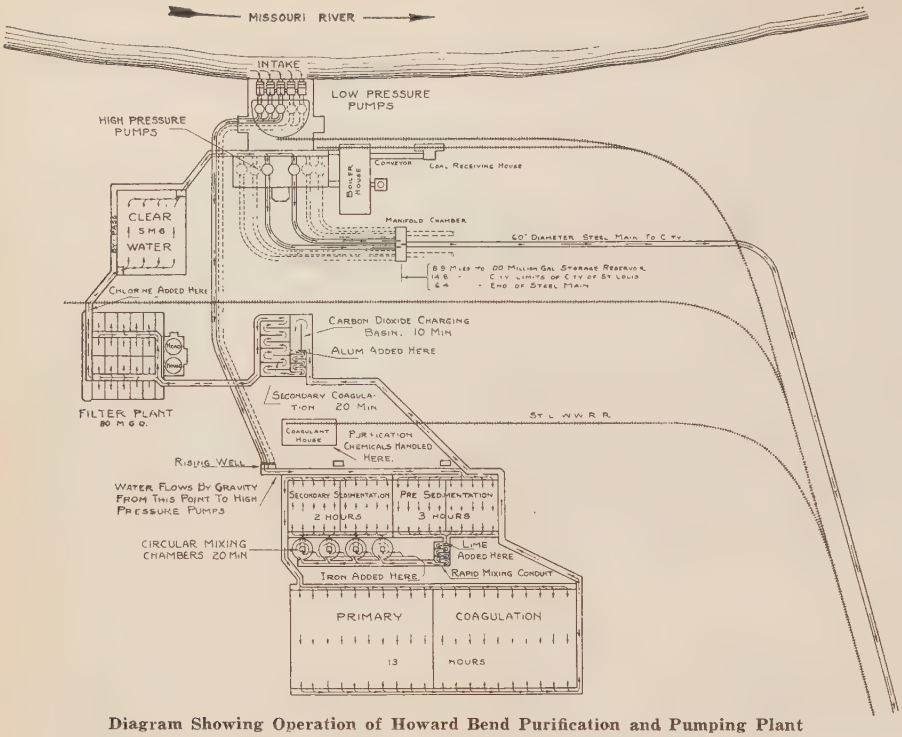


Diagram Showing Operation of Howard Bend Purification and Pumping Plant

minutes' gentle agitation is given the water in the reaction chambers before it is allowed to go into the two coagulation basins, where most of the lime and magnesia precipitated from the water by the chemicals added is removed together with the fine suspended matter not settled out in the preliminary sedimentation basins.

These coagulation basins are also equipped with revolving scrapers for the continuous removal of mud or coagulated sludge. This sludge is usually pumped back into the muddy river water before it enters the preliminary sedimentation basins, as it has been found to greatly accelerate the rate of settling.

The water then flows to the two large sedimentation basins where practically all of the suspended matter not removed by previous treatment settles out. From these basins the water flows to the carbonating basin where it absorbs carbon dioxide from washed flue gas which is bubbled through it. After leaving the carbonating basin the water receives a charge of sulfate of alumina and passes through another rapid mixing conduit into the secondary coagulation basin, from which it flows to the filters.

After being filtered the water receives a small charge of chlorine, then flows into the underground clear water basin from which it is taken by the high pressure pumps and pumped through a 62-in. steel conduit to the 100,000,000 gal. Stacy Park storage reservoir, a distance of 8.9 miles. From this storage reservoir the water flows by gravity to the city through a 62-in. conduit, a distance of 7.5 miles, entering the city mains along Oakland Ave. at various points between Skinker Boulevard and Kings highway.

The pumping equipment at Howard Bend Station consists of three DeLaval centrifugal low pressure pumps delivering river water to the settling basins and two DeLaval centrifugal high pressure pumps, delivering purified water to Stacy Park reservoir, all being driven by steam turbines. Two of the low pressure pumps have a capacity of 60,000,000 gal. each and one a capacity of 120,000,000 gal. per 24 hours, against a dynamic head of 40 ft. Each of the two high pressure pumps have a capacity of 60,000,000 gal. per 24 hours, against a dynamic head of 360 ft.

Purification Process.—The process of purification is partly mechanical and partly chemical. Screens are used to remove sticks, leaves, pebbles, fish, etc.; large particles of suspended matter such as sand and heavy silt are removed in a grit chamber or preliminary sedimentation basins.

Lime is added to soften the water, or reduce its hardness, and to act as a coagulant, while sulfate of iron is added to assist in the proper coagulation.

Sulfate of alumina is added as a secondary coagulant to prepare the water for filtration.

The several reaction chambers or mixing conduits are for the purpose of facilitating coagulation by giving the water a gentle agitation for 20 to 30 minutes.

The filters remove the small amount of suspended matter which has defied sedimentation, and most of the bacteria which have escaped previous treatments.

Chlorine is added to destroy any bacteria which may escape the filters.

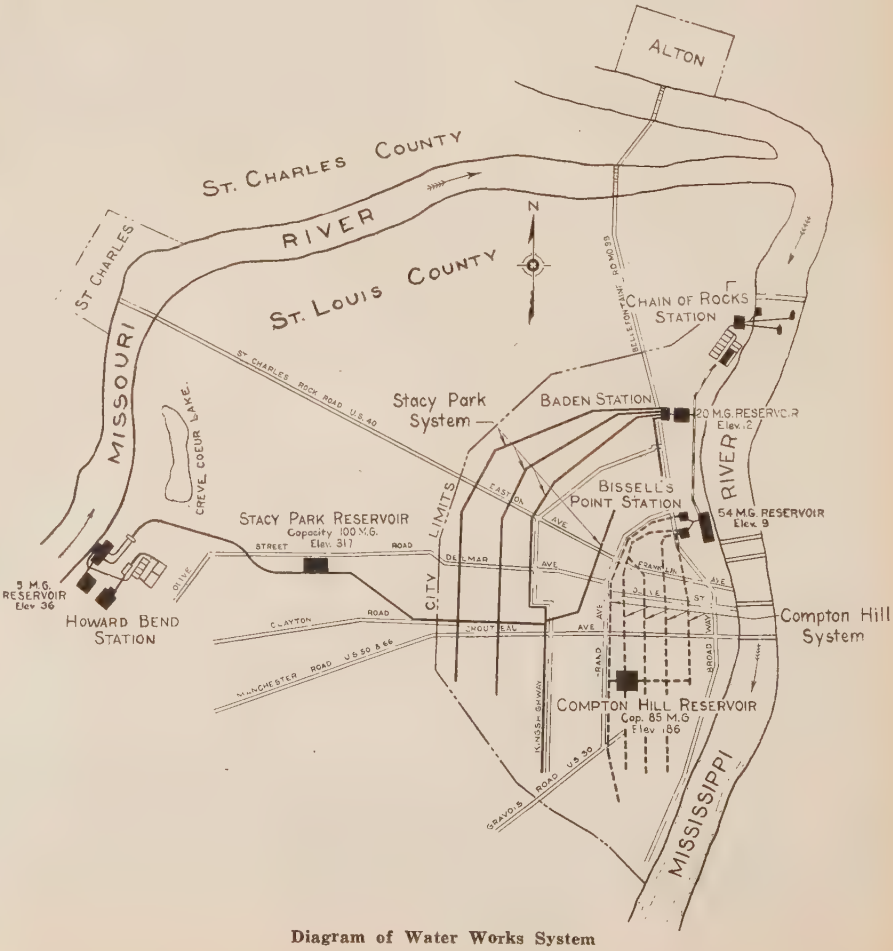
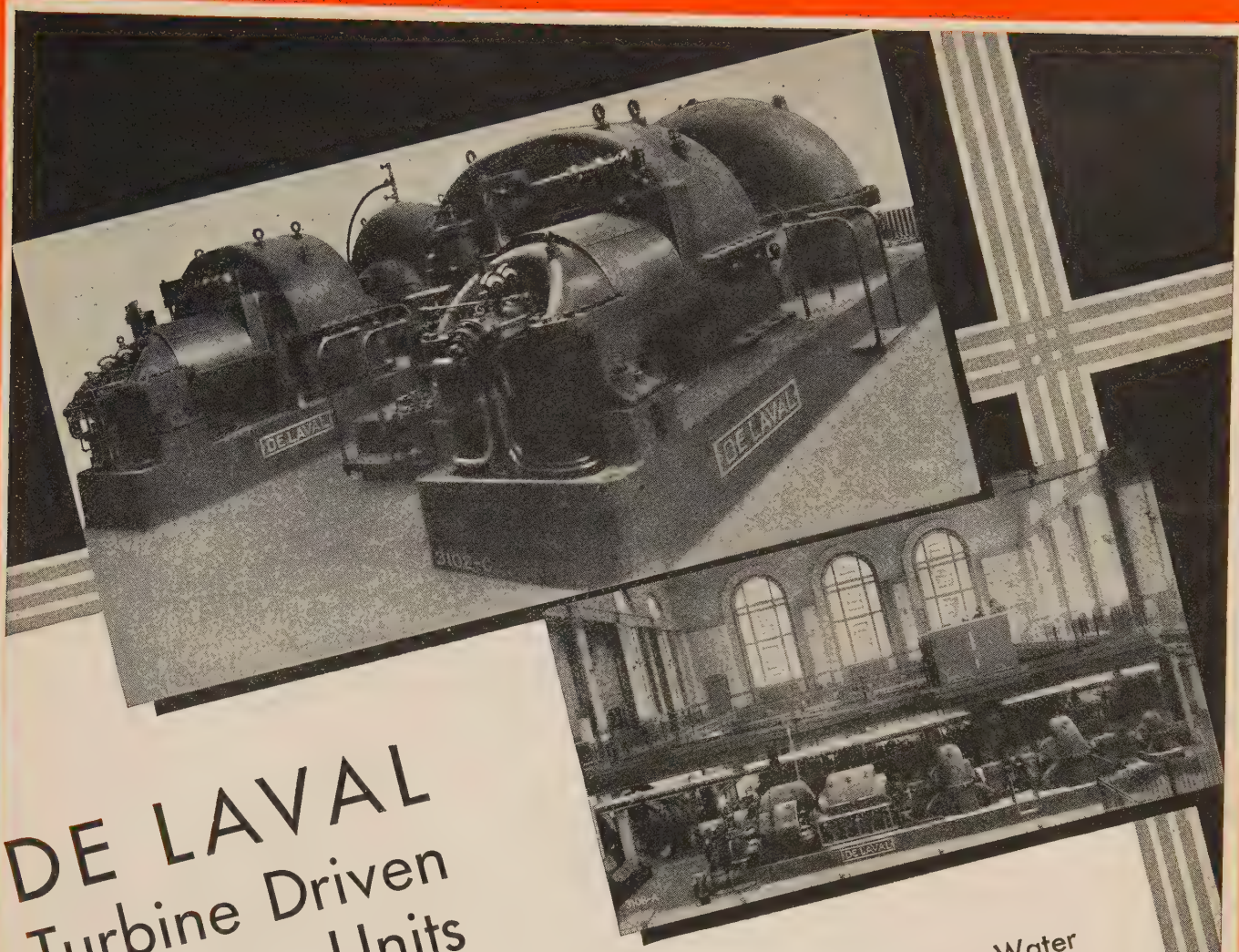


Diagram of Water Works System



DE LAVAL Turbine Driven Pumping Units

at the Howard Bend Station

WHILE attending the Convention of the American Water Works Association at St. Louis, do not fail to visit the new Howard Bend Pumping Station, equipped with De Laval turbine driven pumping units, as shown above.

The two high head units, which are the largest turbine driven pumping units built up to the present time, have a maximum capacity of 60 m.g.d. each against 360 ft. head.

Three turbine driven De Laval low head units are also installed in this station—two rated at 60 m.g.d. each and one at 120 m.g.d., against 40 ft. head.

The Howard Bend Station is representative of the very latest engineering practice and many interesting features are to be found in its design and construction.

The aggregate capacity of De Laval pumps in American municipal water supply systems exceeds 8,000,000,000 gallons per day.

Full information regarding De Laval products will be available at Booths Nos. 76 and 77 in the Convention Hall.

De Laval Steam Turbine Co.
Trenton, N. J.

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The GENERAL Crane does many operations swiftly, efficiently and economically. Crane boom assembly handles dragline, clamshell, backfiller, hook block, or magnet without changes in operating machinery. This wide variety of services is convenient when there are different types of work to be done in a hurry. SIX CYLINDER gasoline engine or single electric motor. The GENERAL may be furnished with electric lights, starter, and oil filter for motor. Give the GENERAL an opportunity to show you some action.

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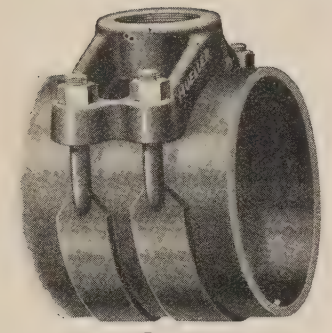
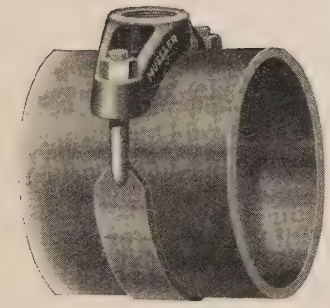


G10450
Tapped Iron Pipe Thread

Lead Ring Gasket



G10515
Tapped Corporation Stop Thread

Lead Ring Gasket

Strap Service Clamps

for every weather and pressure hazard

No matter what the weather or pressure conditions for gas or water services are, there is a Mueller Service Clamp to meet the exact need.

These clamps are malleable iron galvanized and are made on single and double pattern. Clamp curvatures are extremely accurate to assure a close fit to the curve of the pipe.

The boss on every Mueller Service Clamp is amply heavy to permit full depth of thread, which is tapped to template, thus assuring a good, sound joint. All patterns of clamps are furnished with Mueller Patented Lead Ring Gaskets, which fit into a groove on the inner curve of the clamp. All gaskets are molded with ears which are turned up over the edge of the clamps to hold gaskets in the proper position while the clamp is being placed on the main. No leaks possible because gaskets are cast integral.

For ordinary conditions the Single Strap Service Clamp is sufficient, but for severe climates, high pressure or large services, we advise the Double Strap.

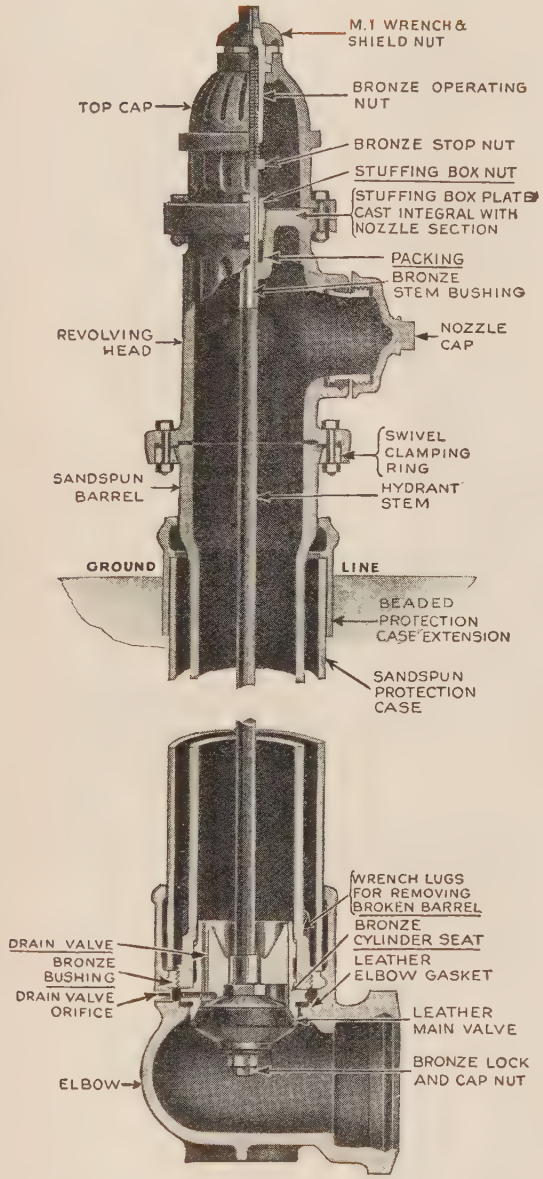
Write for details and prices.

MUELLER CO., (Established 1857) Decatur Illinois. *Branches:* New York, Dallas, Atlanta, San Francisco, Los Angeles, Chicago. *Canadian Factory:* MUELLER, Limited, Sarnia.

MUELLER

The MATHEWS Modernized Hydrant Fulfills All Your Demands

IT SOLVES THE BROKEN HYDRANT PROBLEM



The Greatest Improvement in Hydrant Design in Sixty four Years

NEW and unique features make the Mathews Modernized Hydrant more desirable than ever: simplified in design; greater protection throughout against rust; greater shock resisting strength of the Sand-Spun barrel and protection case; the new swivel flange that permits taking off the nozzle section before lifting out the barrel, thus making this operation easier.

The new swivel flange permits the facing of nozzles in any direction quickly without removing the bolts or disturbing the barrel. The new *shield*-operating nut prevents rain and sleet from seeping down and freezing around the operating nut.

With all these improvements, *the Mathews Modernized Hydrant is interchangeable with old installations.*

As a result of more traffic accidents, an increasing number of hydrants are being broken. On this point alone, the Mathews saves large sums for the municipalities which have them.

A broken Mathews cannot leak, and it can be replaced easily in a few minutes without digging or breaking the pavement.

Mathews Hydrants have been the leader for more than half a century — over 300,000 of them are in use. Avoid having to dig up streets and break pavements to replace broken hydrants. Install Mathews. Write for complete description of the new

MATHEWS MODERNIZED HYDRANT

GATE VALVES
VALVE BOXES
FLOOR STANDS

R. D. WOOD & CO.

ESTABLISHED 1803

400 Chestnut Street :-: Philadelphia

CAST IRON PIPE
SAND SPUN
(centrifugally cast)
and PIT CAST
Reg. U. S. Pat. Off.

General View of Howard Bend Station

At the Howard Bend plant carbon dioxide is added ahead of the alum whereby the amount of this chemical required is reduced. The coating of filter sand with lime salts and the encrusting of distribution mains, meters, etc., is prevented to a large extent by this carbonation treatment.

Results of Purification.—The average results of the purification process are:

(a) A reduction in hardness from 189 to 103 parts per million, thereby effecting a saving in soap cost to the consumers of $1.72 for every 1,000 gal. of water used for washing and bathing purposes.

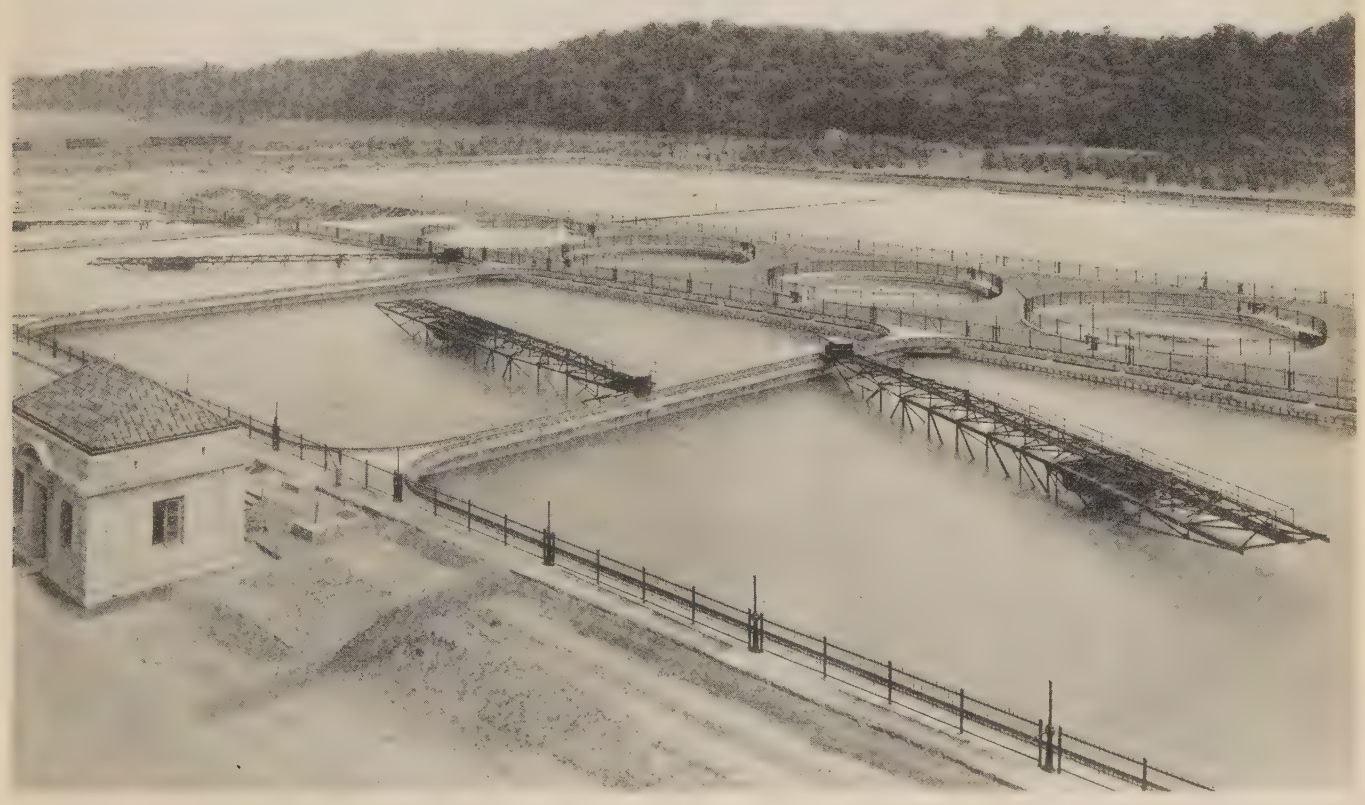
(b) A reduction in scale forming compounds from 1.59 lb. to 0.81 lb. per 1,000 gal. of water, thereby effecting a saving in fuel where water is used for boiler purposes.

(c) The complete elimination of all harmful bacteria with an attendant reduction in the number of cases of water borne diseases, especially typhoid.

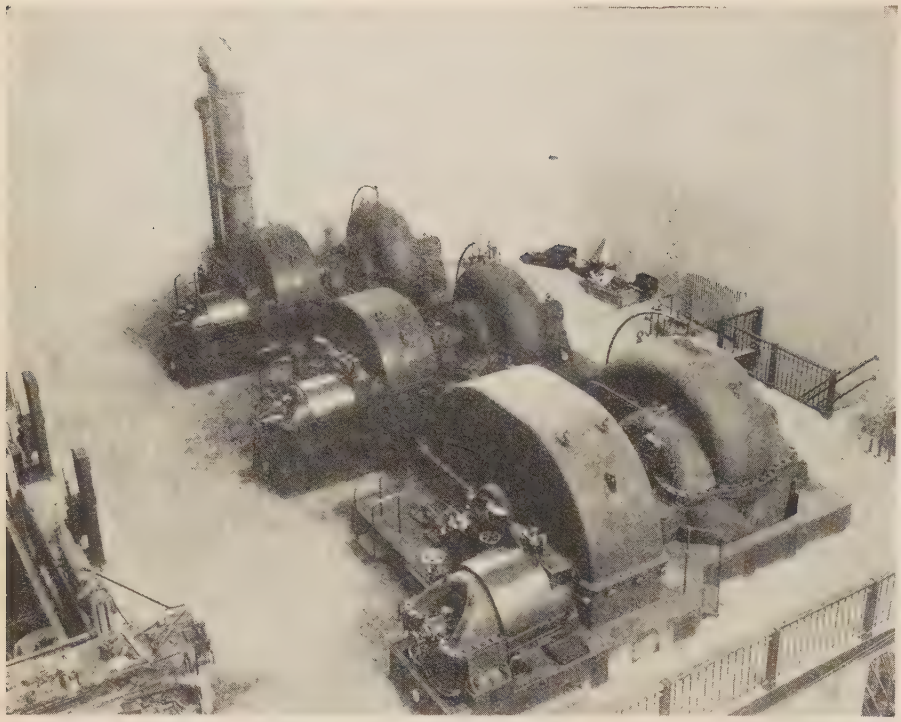
(d) A reduction in color from 17 to 9 parts per million and a reduction in suspended solids from 1,250 to zero parts per million, thereby producing a clear and sparkling water.

(e) A complete removal of all odors and objectionable tastes.

The Distribution System.—The distribution system within the city limits consists of 1,136 miles of pipe, in sizes ranging from 6 in. to 48 in. in diam-



Howard Bend Basins



Howard Bend Low Pressure Pumps

eter. All of this pipe, with the exception of five miles of 36-in. steel pipe, is cast iron.

All service pipes must be either lead, copper or cast iron, and are installed and maintained at the expense of the property owner.

There are 146,895 service connections, of which 12,603 are metered. While the number of metered service connections represent only 8.6 per cent of the total number, the amount of water used through these connections amounts to approximately 50 per cent of the total water consumption of the city.

There are four service stations located in eastern, western, southern and northern parts of the city, at which a sufficient number of men are kept to take care of the repairs and maintenance of the distribution system.

A force of 30 inspectors is busy investigating complaints and inspecting plumbing fixtures and trying to eliminate water waste, and four men are checking meters to see that they are registering accurately.

All pipe is laid by Water Division forces. The Distributing Section of the Water Division is equipped with four trenching machines, two cranes, three air compressors, 31 trucks and 27 automobiles which are used for the maintenance and extensions of the distribution system.

Transportation.—As a necessary adjunct to the foregoing equipment, the Water Division owns and operates a combined steam and electric railway, about 7¾ miles long, extending from Bissell's Point to the Chain of Rocks. This railway handles all coal and supplies for the Bissell's Point, Baden and Chain of Rocks Stations and carries employes to the Chain of Rocks. Employes are transported from the city to the Howard Bend Station by means of large automobile busses, and all coal and supplies for the station are handled from the Rock Island Railway with gasoline locomotives.

Water Works Parks.—All land around the several stations and reservoirs is being made into beautiful parks. This land consists of 300 acres at the Chain of Rocks, including 3½ miles of river front; 44 acres at Baden Station; 98 acres at Bissell's Point, with one-half mile of river frontage; 40 acres at Compton Hill reservoir; 53 acres at Stacy Park reservoir; and 240 acres at Howard Bend Station, including ¾ mile of river frontage and 46 acres on the bluff between the station and Olive Street Road. This constitutes a total area of 775 acres.

Plants and trees for landscaping these grounds are grown in the Water Division nursery and greenhouses.

The Chain of Rocks Park is a naturally wooded hillside overlooking the station affording an unusual view of an extensive reach of the Mississippi River, the nearby Illinois towns and the distant city. This park is very popular with the public as a place for picnics and recreation.

The Bissell's Point Park is now in course of development. It fronts upon the Mississippi River, surrounds the Bissell's Point Station and storage basins and contains the Naval Reserve Station.

Compton Hill Park surrounds the reservoir in an attractive residential district and is much used by the neighborhood as a recreation place.

Stacy Park, lying about the reservoir of that name, is also in the development stage. Situated upon the highest ground in the vicinity of St. Louis, it affords a panoramic view of the surrounding country for many miles.

The station site at Howard Bend is being developed into a park which is intended to rival the beauty of the one at the Chain of Rocks.

Summary of Statistics.—The following figures are for the year ending April 1, 1930:

Physical value of water works	$45,681,252
Bonded debt	12,082,000

Howard Bend Boiler Room

Storage

In process of purification:	Gal.
Chain of Rocks	295,000,000
Howard Bend	45,000,000
Total	340,000,000
Capacity of filtered water basins:	
For distribution by pumping—	Gal.
Baden storage basin	20,000,000
Bissell's Point storage basins	54,000,000
Howard Bend clear water basin	5,000,000
Total	79,000,000
For ditribution after pumping—	
Compton Hill Reservoir	85,000,000
Stacy Park Reservoir	100,000,000
Total	185,000,00
Total filtered water storage	264,000,000

Consumption of Water

Estimated total population served	900,000
	Gal.
Total consumption for year	44,903,936,000
Maximum daily consumption, June 22, 1929	164,000,000
Minimum daily consumption, May 5, 1929	90,400,000
Average daily consumption	123,024,000
Average per day to each person	137

Pumping Capacity

From River to Settling Basins:

	Mil. Gal Per 24 Hrs.
Chain of Rocks Station	320
Howard Bend Station	240
Total	560
To Distribution System:	
Baden Station	80
Bissell's Point Station	140
Howard Bend Station	120
Total	340

Purification

Type of filters—gravity, mechanical.
Rated capacity:

	Mil. Gal Per 24 Hrs.
Chain of Rocks	160
Howard Bend	80
Total filter capacity	240

Results of Purification

Impurities	Raw Water	Purified Water	Per Cent Reduction
Suspended matter, parts per million	1,250	0	100
Dissolved matter, parts per million	312	227	27
Color, parts per million	17	9	47
Hardness, parts per million	189	103	46

Impurities	Raw Water	Purified Water	Per Cent Reduction
Scale forming solids, pounds per 1,000 gal	1.59	0.81	49
Bacteria, all kinds; number per milliliter	4,200	10	99.76
B. coli; number per 100 milliliters	2,660	0.02	99.999
Pounds of mud removed from each million gallons of water			11,100

Chemical Data

Chemicals used during year:	Tons
Lime	18,771
Iron	2,320
Alum	3,703
Chlorine	82.6

Distribution System

Mains:
Kind of pipe, cast iron and steel
Sizes, from 6-in. to 48-in.—

	Ft.
48-in. pipe	1,341
36-in. pipe	238,493
30-in. pipe	159,691
20-in. pipe	508,077
15-in. pipe	53,559
12-in. pipe	1,065,419
10-in. pipe	49,859
8-in. pipe	227,381
6-in. pipe	3,694,748
	5,998,568 = 1,136.1 miles

Range of pressures in mains, 20 to 25 lb. per sq. in.
Number of fire hydrants (public and private) now in use, 13,859

Service Connections

Kind of pipe, lead, cast iron and copper
Sizes, ⅝ in. to 12 in.

Number of flat rate service connections now in use	134,292
Number of meters now in use	12,603
Total number of connections	146,895

Vital Statistics

	1903	1913	1928	1929
Deaths per 100,000 from all diseases	1,681	1,389	1,420	1,390
Deaths per 100,000 from typhoid	47	17	2.23	1.5

Personnel.—The officials of the city and of the St. Louis Water Works are: Mayor, Victor J. Miller; Comptroller, Louis Nolte; Board of Public Service: Edmund R. Kinsey, President; Robert B. Brooks, Director Street and Sewers; J. L. Rilliet, Jr., Director Public Utilities; Harry L. Salisbury, Director Publice Welfare; Edward A. Steininger, Director Public Safety; Water Commissioner, Leonard A. Day; Engineers in Charge: Supply and Purifying Section, E. E. Easterday; Operating Section, H. Clay Henning; Distribution Section, Thos J. Skinker; Assessment Section, S. O. Schumacher.

State and Municipal Bond Election in April.—According to the "Daily Bond Buyer," bond authorizations reported by 180 communities during April aggregated $45,325,479, the largest total for any of the first four months of the year. The figure for April of last year was $37,963,300; for 1928, $77,465,239, and for 1927, $75,778,049.

Chain of Rocks Pumping Station

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Filtration Engineer, Bureau of Engineering, Chicago, Ill.

Factors Influencing the Toughness of Coagulated Matter

A DISCUSSION of the make-up of the gelatinous precipitates of iron and aluminum, and the way in which such precipitates remove the suspended matter from water was given in the May issue. It was assumed that such precipitates were composed of a meshwork of entangled fibers, such assumption being in accordance with the generally accepted theories as to the formation of many and perhaps most gelatinous precipitates. The fibrous formation is built up from minute solid particles wihch coalesce after neutralization or partial neutralization of the positive electrical charge on the particles. As to what produces the coalescence is not known, but it is known that there is something which holds the solids together when they collide. The present article is a continuation of the discussion on coagulation, and is limited largely to the factors which influence the strength of the flocculated matter formed by the hydrous oxides of aluminum and iron when water is coagulated.

Micro-organisms Cause Short Filter Runs.—Many are aware that there is considerable variation in the strength of the coagulated matter from time to time due to the presence of microörganisms in the water, but we know very little about the causes for variation in the toughness when microörganisms are not present. It is easy to conceive how microörganisms add toughness to the flocculated matter, for it is somewhat like adding steel reinforcing to concrete to make it stronger, but it is not so easy to see how the strength may be affected materially by other factors. When certain forms of organisms are present they may form a mat at the surface of the sand so tough there is practically no penetration of the coagulated matter into the sand beds. This causes the loss of head to increase rapidly and gives very short filter runs. How microörganisms affect the filter runs has been explained.[1] We shall now discuss factors other than microörganisms that influence the toughness or the strength of the precipitates of hydrous oxides of aluminum and iron in coagulating water prior to filtration.

Coagulated Matter Passing Filter Beds.—Most filter operators in localities where the water temperature goes nearly to the freezing point in winter have had difficulty with suspended matter passing the filter beds when they felt that the water was properly coagulated. This is usually called an "after precipitation," or "coagulation after filtration." As a matter of fact in most instances it is merely coagulated matter which has once been formed and flocculated perfectly but is too weak in structure to prevent the larger masses being broken up into a number of finer masses that will pass through the filter beds when a little pressure is exerted on the beds due to the loss of head increasing.

The cause for the formation of the weakly formed flocculation is difficult to determine, unless the gelatinous precipitate is naturally weak and the strength we get in water treatment is due largely to the suspended matter or turbidity in the water. Filter operators frequently express their preference for a water fairly turbid over fairly clear water, and the reason for this may be that the turbid water produces a stronger flocculation. It produces a heavier precipitate that settles clearer than the less turbid water, but in addition to this it seems to give strength to the material that does not settle out before the water reaches the filters.

The writer will give his own observations as to the probable causes for some of the variations in the strength of coagulated matter. In some instances the assumptions seem fairly well supported by experimental data, but in other instances little is known. Figure 1 shows the enormous amount of coagulated matter that will pass through sand beds under conditions of weak coagulation. The volume of the coagulated matter is based upon the volume per million volumes of water; that is, 10 volumes of coagulated matter is 10 gallons of compact flocculated matter per million gallons of water.

Supersaturation of the Hydrous Oxides Reduced Rapidly.—When aluminum sulfate is added to water containing sufficient alkalinity for coagulation to take place, the reaction of the sulfate with the alkali liberates the hydrous oxide of aluminum and produces considerable supersaturation. This causes minute solid particles or crystals to form in large numbers, which quickly reduce the supersaturation nearly to the point where there is no supersaturation. The reduction in supersaturation may be nearly complete before the minute particles have coalesced into chains or fibers. In the formation of crystals from a highly supersaturated solution the number of particles which form all start forming within a very short time, and in some instances within two or three seconds after the formation of the supersaturation. The particles, of course, keep increasing in size so long as the solution is supersaturated, but they do not keep increasing in number.

We have no evidence that the total number of solid particles which form when aluminum sulfate is added to water reaches the maximum within two or three seconds, but the time is quite short. This also applies to the iron compounds used in water treatment. If the saturation point of the hydrous oxide of aluminum or iron is only about 0.2 part per million, and sufficient coagulant is added to produce 4.0 parts per million of the hydrous oxide, then the supersaturation is about 20 times the normal saturation. This is considerable supersaturation and causes the formation of a large number of minute solids very quickly. By the time the solid particles start coalescing into chains the supersaturation is nearly exhausted. This means that after coalescing there is practically no excess of the hydrous oxide to build the chains or fibers larger in diameter. In other words, we cannot count on the fibers that go to make up the gelatinous precipitate getting much stronger than they are when first formed.

Formation of Flocculated Particles.—Explanation was given in the May issue as to how the minute solids of the hydrous oxides became positively charged, how the charge was neutralized, and how coalescence took place with the formation of a gelatinous precipitate. It is believed that the formation of the flocculated particles may be

[1]Baylis, John R., and Gerstein, H. H. Microörganisms in the Lake Michigan water at Chicago. Municipal News and Water Works, 76:7, 291-6, July, 1929.

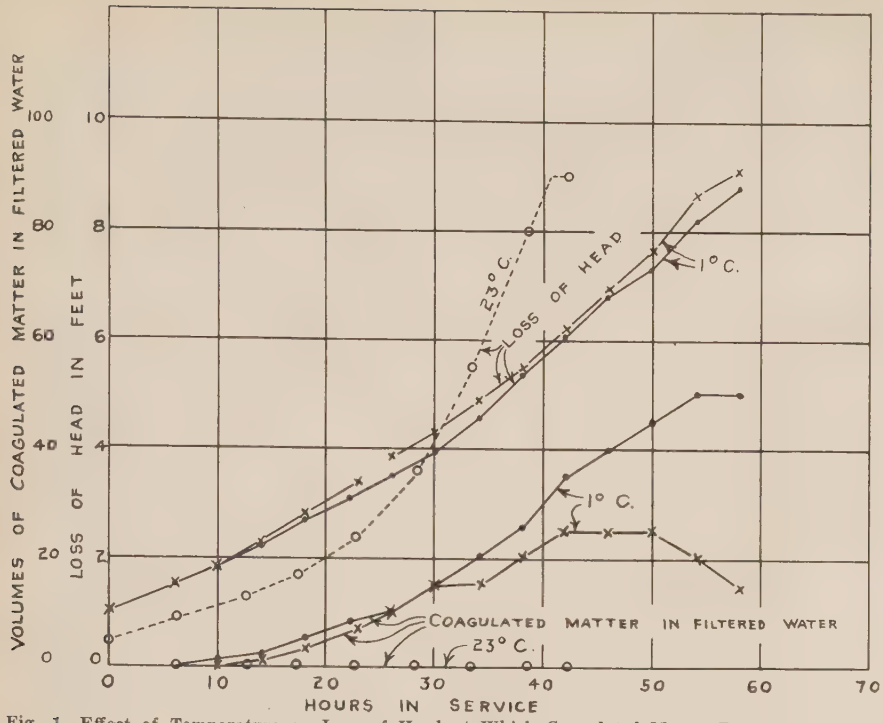


Fig. 1—Effect of Temperature on Loss of Head at Which Coagulated Matter Began to Pass the Filter Beds

explained best by the illustration in Fig. 2. The sketch on the left illustrates coalescence taking place to form chains of the minute solids, which will be designated as fibers or filaments. After the fibers or filaments have formed they begin to become entangled one with another. In fact they probably have a slight attractive force for each other, and probably coalesce where they touch just as firmly as any of the solids that go to make up the filaments have coalesced. If the supersaturation of the solution has not been quite exhausted of the hydrous oxide then the fibers probably build slightly larger in diameter, which no doubt will add considerable strength to them. In water treatment it is believed that the solution is so nearly exhausted of its supersaturation that we can count on but little strength being added to the coagulated matter in this manner. Whatever is the cause of coalescence, it is this force that largely determines the strength of the individual fibers of filaments that go to make up the gelatinous precipitates of aluminum and iron.

After the addition of the coagulant in filtration plants the water is kept in motion to hasten the entanglement of the fibers to form the flocculation. The first flocculation is composed of very small masses, which may be illustrated by the center sketch in Fig. 2. No free-floating or unattached fibers or spherules are shown, though it is evident the flocculation is not so perfect as shown by the sketch. There is a beginning of the union of the small flocculated particles into larger masses before all the fibers have become attached or entangled. By the time the first flocculation has formed it is believed there is almost no supersaturation of the hydrous oxide, and that the number of unattached fibers are so few they are not capable of materially adding to the strength of the larger masses of flocculated matter. Then it would seem that the strength of the coagulated matter which has no reinforcement is determined by what takes place within the first minute after the coagulant is added to the water.

The large particles of flocculated matter so desirable for good sedimentation in water treatment are not built directly from the entanglement of a few fibers which gradually grow in size as more fibers become entangled, but are composed of a number of small flocculated masses which have joined together. If the grouping together of the fibers or filaments first form small flocculated masses as shown by the center sketch in Fig. 2, and it is evident that they do, then the only way the large particle shown by the sketch on the right can form is for the small flocculated masses to unite. The small flocculated masses may be joined together with considerable strength, but they are so small they readily pass through the filter beds when in considerable number in the water. Therefore, the toughness of the large flocculated masses is dependent upon the strength with which the small flocculated masses hold to each other and not upon the strength of the small individual masses as illustrated in the center sketch. This is assuming that there is nothing suspended in the water such as microörganisms and strong gelatinous compounds that may possess strength much greater than that of the coagulant. There is a maximum strength of coagulated matter which is possible to produce, but just how much this strength may be varied by varying the treatment is not known. It is believed that temperature has the greatest influence, the strength increasing as the temperature increases when other factors are the same. This will be discussed more fully in another paragraph.

Perhaps the weakness of the large particles of flocculated matter may be illustrated by comparing with a "brush heap" of small trees. The individual trees, which may be represented by the small flocculated particles shown in the center sketch of Fig. 2, with their many branches hold together with considerable strength, but the "brush heap" itself does not hold together so firmly. It may require less force to pull apart a "brush heap" composed of 100 trees than to pull one tree in two. This may not be a very good comparison for the coalescing force of the fibers that go to make up the gelatinous mass may not be so great as expected. Also the fibers of the flocculated masses where they touch may coalesce just as firmly as any part of the fiber, whereas the limbs of the tree do not adhere where they touch the limbs of other trees. However, it may require nearly as much force to pull in two one of the small flocculated masses made up from an entanglement of individual fibers as is required to pull apart a large mass com-

Fig. 2—Sketches Showing Formation of Flocculated Particles

posed of hundreds of smaller masses. It would be practically impossible to produce enough agitation in the water to break up the flocculated masses to a size less than the first flocculation, but it is not difficult to break the large masses into smaller masses with only moderate agitation.

What makes the small flocculated particles coalesce or join together into larger particles? Is there an attraction of one particle of flocculated matter for another just as there is between the minute solids that build up the fibers? Some colloidal chemists are of the opinion that the coalescence of the minute solid particles that make up the fibers is brought about by two particles colliding in the water and not to an attraction; that is, there is no attractive force so long as the two solids are apart or at least until the solids have come so close together they have penetrated the outer layers of the electrical double layer which surrounds the charged particles. In the discussion of coagulation given in the May issue it was shown that there was an attraction between the chains of solids of calcium carbonate and the unattached solids more strongly at the end of the chains than along the sides, and that the zone of influence was a distance much greater than is generally thought to be the case. This would suggest an attraction of the fibers for each other and probably a very slight attraction of the flocculated particles for each other.

Even though there may be a slight attractive force of the flocculated masses for each other, it is believed that the colliding of the coagulated particles as they float around in the water is decidedly the main way in which the masses are brought together into larger masses. After the masses strike, then what holds them together? Is it merely the coalescing force of the fibers that happen to touch each other, or an entanglement of the fibers on the surface of the mass as the limbs of the small trees become entangled with each other when piled together? If there is a force that holds the minute particles

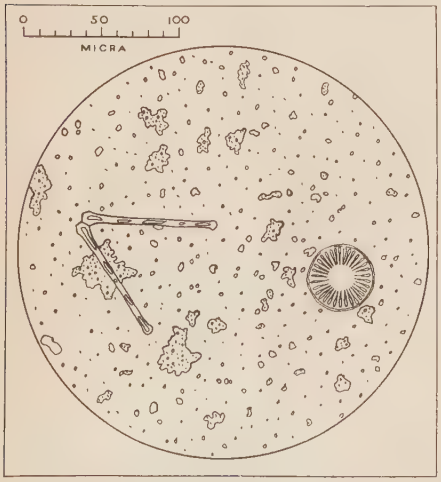


Fig. 3—Suspended Matter in Raw Water for Run No. 2

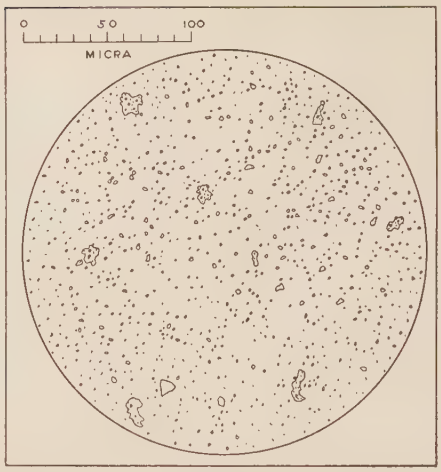


Fig. 4—Suspended Matter in Raw Water for Run No. 3

together when they strike each other, or even an attraction at the ends of the fibers, then it seems that such fibers as actually touch each other when two masses of flocculated matter come together may be held together with at least its coalescing force. The writer is of the opinion that the binding force is due mainly to the fibers on the surface becoming entangled with each other, and only to a slight extent to the coalescing force.

Coagulants are used in such small quantities in water treatment that it may not be possible to vary the strength of the flocculated matter to any material extent by changes that may be brought about in a filtration plant. We have hopes that when we know more about the factors that influence the strength we may be able to increase the strength within certain limits. If the gelatinous precipitate cannot be made stronger in the winter months, which is the time of weakest coagulation, then this should be taken into consideration in the design of the plant by providing longer periods of mixing and settling so as to remove as much of the flocculated matter as possible before it reaches the filter beds. Temperature has an effect, but it is not practical, neither is it desirable to raise the temperature of the water merely to form a tougher coagulation. It seems possible that variations in the coalescing force may be produced, but at the present time we have no idea how this may be done.

Effect of Temperature on the Strength of Coagulated Matter.—Temperature apparently has some effect upon the strength of coagulated matter. This is indicated by the variations in the flocculated matter passing filter beds as shown in Fig. 1. Treating water from the same source at 23° C. and 1° C. with the same amount of coagulant, it is noted that the loss of head for the higher temperature went to 9.0 ft. without any coagulated matter passing the sand bed whereas that treated at 1° began to pass coagulated matter at 2.0 ft. loss of head. This indicates a stronger coagulation for the higher temperature, though the two experiments were not run exactly alike and this may have had considerable influence. The runs for the lower temperature were made by taking water from the settling basin in a filtration plant and running it through a glass tube filter having sand of about 0.5 mm. for the 10 per cent size. The water for the higher temperature was coagulated and settled in the laboratory, and then filtered through a sand bed of the same size sand as was used to filter the cold water.

There was less coagulated matter in the warmer water after settling than in the colder water. Perhaps the difference due to the stirring in the laboratory, and more complete settling, was the major factor instead of the temperature. But there is such a wide difference in the results it is not believed that factors other than temperature could have been mainly responsible. That the amount of coagulated matter going to the filters had some influence, there is not much doubt, yet it is not believed that this could have been the major factor. Plant results with more complete settling than was the case for the runs plotted in Fig. 1 indicate that a higher loss of head could be obtained without coagulated matter passing than with considerable coagulated matter going to the filters, so this very likely was partially responsible. Even though there were several factors that may have lessened the effect of temperature as indicated by Fig. 1, it is believed that temperature was the major factor in producing the differences shown.

Effect of Suspended Matter in the Water on the Strength of the Flocculated Matter.—When microörganisms are not present, it is believed that the character of the suspended matter in water produces the greatest variations in the strength of the flocculated matter. There, of course, is nothing likely to effect the filter runs as do microörganisms, for they may vary the runs from about 2 hours with an abundance of microörganisms of certain kinds to

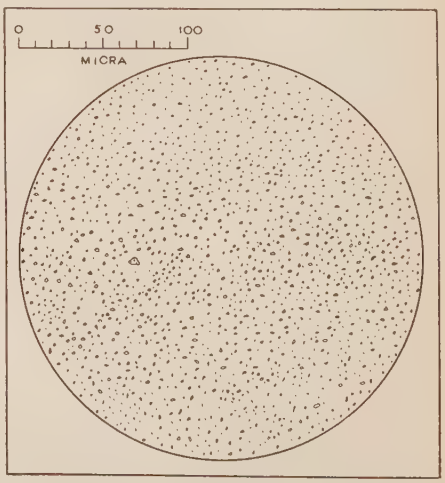


Fig. 5—Suspended Matter in Raw Water for Run No. 5

runs of perhaps 100 hours or more when none are present. Factors other than microörganisms do not vary the filter runs nearly so much, though there still may be considerable difference. If the condition of weakest coagulation is when the water contains no suspended matter and when the temperature is near the freezing point, and this gives filter runs of 100 hours before the loss of head reaches 8 ft., then any shortening of the runs will indicate a stronger flocculation, either from the coagulant itself or its reinforcement with the suspended matter in the water.

With everything else equal we may expect filter runs much shorter at 20° C. than 1° C., sometimes perhaps only one-half as long. With the suspended matter before coagulation of a nature that gives no reinforcement to the coagulated matter, it is likely that no coagulated matter will pass through filter beds at 8 ft. loss of head when the temperature is 20°, whereas at the lower temperature it may start passing before the loss of head reaches 3 ft. Just how much the actual toughness of the coagulated matter is increased due to an increase in temperature there is no way of telling, but it is believed to be anywhere from 25 to 100 per cent stronger at 20° than at 1°. With the temperature near the freezing point and water containing considerable turbidity, but no microörganisms, the runs may vary from 20 to 100 hours, depending on the character of the suspended matter before coagulation. In the warmer months the runs under the same condition of turbidity may vary probably from 10 to 50 hours.

In order to obtain some information as to why the filter runs vary greatly when microörganisms are not present, a study of the turbidity in a certain water was made with the microscope. The drawings in Figs. 3, 4 and 5 show variations in the character of the suspended matter of this water from time to time. Fig. 3 contains microörganisms, but they were of a negligible quantity in the water used for the other drawings. The drawings shown in Figs. 3 and 4 are camera lucida drawings, and Fig. 5 was made from careful observations on the suspended matter with a microscope, but it is not a camera lucida drawing. Table I gives variations in the time required for the loss head to reach 8 ft. when water with and without chemical treatment was run through sand beds of about 0.5 mm. diameter for the 10 per cent size.

It was not expected that the water without chemical treatment would filter clear. The tests were run to get some idea of the amount of suspended matter in the water that was of sufficient size to clog filters. It will be noted that the filter runs in the plant vary in the same direction as those of the filter using water without chemical treatment. In runs No. 1 and No. 2 it is evident that microörganisms were largely responsible for the very short runs. There were practically no microörganisms present for the other runs, yet they varied from 5 to 145 hours for the water that had not been coagulated, and from 22 to 122 hours for the same water in a filtration plant where there was good coagulation and good settling. The gelatinous matter naturally in the water materially strengthened the flocculated matter in some of the runs. Run No. 5 was only slightly more than one-fifth that of run No. 4, and there was very little variation in the temperature. The camera lucida drawing shown in Fig. 3 was the water for run No. 2, the drawing in Fig. 4 for run No. 3, and the drawing in Fig. 5, while not a camera lucida drawing, was characteristic of the water for run No. 4.

Volume of Coagulated Matter in Water Going to Filters Should Be Low When the Water Temperature Is Near the Freezing Point.—There is another factor that has influence on the effectiveness of the filter bed in removing coagulated matter from the water, and that is the rate at which the coagulated matter goes to the bed. Assuming the rate of filtration to be constant and other conditions the same, except the amount of flocculated matter, there is a limit to the amount that may be in the water for all of it to be filtered out when the loss of head has increased to near the maximum. Any increase over a certain amount will cause flocculated matter to pass the beds before the maximum loss of head is reached. If the rate of filtration is lowered, then more flocculated matter may be present and be filtered out, and if the rate is increased the amount of flocculated matter has to be decreased. These are facts fairly well known to filter operators. As a rule, when rates of filtration not greater than 2 gal. per square foot per minute are used, there is not much trouble from flocculated matter passing the filter beds where there is fairly good sedimentation before filtration, except when the water is near the freezing point.

To take care of the times of very weak flocculation which occurs when the water is cold, so that filters with sand of about 0.5 mm. size and 24 in. in depth will run to 8 ft. loss of head without passing flocculated matter, the water in many filtration plants would have to be settled to where the flocculated turbidity is not greater than 2 to 3, and perhaps even less in some plants. It is not possible to settle to this low turbidity in most filtration plants as now constructed. Finer sand and deeper beds will help, but fine sand produces so much trouble in the summer months that it is not practical to use sand finer than about 0.4 mm. In some plants increasing the amount of coagulant will result in less flocculated matter going to the filters, but we cannot rely on this with safety, for when the raw water turbidity is low, increasing the amount may increase the amount of flocculated matter going to the filters. There is no difficulty in getting runs of 24 to 36 hours in the average rapid sand filtration plant without coagulated matter passing if the flocculated turbidity is settled to where only a turbidity of about 5 remains in the water. The loss of head may not go higher than 2 to 3 ft. within this time, but a run of 24 hours does not produce undue operating troubles.

Flocculated Matter Is Compacted in the Filter Beds.—Now we come to the question, why will the loss of head on a filter go higher without flocculated matter passing the bed when the volume of the flocculated matter going to the filter is low? Considerable thought has been given to why this is the case. It is believed to be due to compacting the flocculated matter that has filtered out as the pressure on the filter increases due to the clogging. Going back to the structural formation of gelatinous precipitates as illustrated in the May issue, it was shown that the actual volume occupied by the fibers was only a small percentage of the total volume of the gelatinous mass. It seems reasonable to believe that part of the water of such precipitates may be squeezed out as the loss of head on the filter increases. The squeezing out of the water no doubt is a slow process, and if the volume of the flocculated matter going to the beds is large it cannot be compacted quick enough to keep it from breaking up and being forced on through the beds.

The compacting of the flocculated matter on the surface and within the sand beds is believed to be a very important factor in filtration. Not only does the flocculated matter occupy a less volume, but the compacting causes the mass to adhere more firmly so it is not easily broken up into smaller masses that may be forced on through the filter beds. Examination of the coagulated matter being washed from a filter after it has reached its maxi-

Table I—Comparison of Filter Runs with Varying Character of Turbidity

Run No.	Turbidity Raw Water	Plant Results: Water Not Coagulated, Turbidity After Filtering	Plant Results: Water Not Coagulated, Length of Filter Runs in Hours	Plant Results: Water Coagulated and Settled, Volumes of Flocculated Matter in Filtered Water	Plant Results: Water Coagulated and Settled, Length of Filter Runs in Plant
1	9*	2.6	2.5	.0	5.5
2	75*	8.0	1.0	.0	20.2
3	130	20.0	5.0	.0	77.1
4	125	45.0	14.0	30.0	100.0
5	155	27.0	7.3	.0	22.1
6	65	25.0	38.0	30.0	100.0
7	49	20.0	42.4	15.0	64.5
8	22	10.0	145.0	20.0	122.0

*Microörganisms present.

mum loss of head reveals much of the coagulated matter in a very much more compact form than it was in the water going to the filter.

The actual voids in a sand bed probably are about 45 per cent of the volume of the bed. Perhaps 20 to 40 per cent of this void area is capable of being filled with the material filtered from the water. A bed 24 in. deep probably will have an area of about 0.2 to 0.4 cu. ft. per square foot of the bed capable of being filled with the flocculated matter. If the filter runs for a period of 100 hours at a rate of 2 gal. per square foot per minute, 12,000 gal. of water will be filtered for each square foot of filter surface. With a flocculated turbidity of 5, the volume of flocculated matter in the 12,000 gal. of water is somewhere near 0.1 cu. ft. Now it would seem that the void area in the sand capable of being filled is ample, for much of the flocculated matter is compacted quite materially. Usually it is ample, but when the water is near the freezing point there are a few plants that will pass some flocculated matter.

When the flocculated matter is very weak it penetrates into the sand more readily and by the time voids in the upper 12 in. of the sand are partially filled, flocculated matter will begin passing the beds which are only about 24 in. in depth. It cannot be assumed that the 0.2 to 0.4 cu. ft. of void volume per square foot of filter area is all available, or that even one-half of it is available, for there must be a filtration zone which may be only a few inches in depth for the finer sand near the surface of the beds though it very likely is a foot or more for the coarse sand near the bottom of the beds. By the time a large percentage of the flocculated matter is extending 6 to 8 in. below the surface before being filtered out, flocculated matter may start passing through the beds.

If the flocculated turbidity in the water going to the filters is increased, then the time required to fill the voids in the upper part of the bed is decreased, perhaps in a ratio greater than the increase in volume, for the matter filtered out does not have time to become compacted as much as it would be when a smaller volume is going on to the bed. We should expect flocculated matter to pass a filter bed, when twice the volume goes on to the bed, within less than one-half the time for the lesser volume; that is, if with a flocculated turbidity of 5 it is 100 hours before flocculated matter begins to pass the bed it might start passing within 40 hours if the turbidity was 10.

Summary.—The factors that influence the strength of the coagulated matter in water treatment may be summarized as follows:

Microörganisms have the greatest influence in shortening filter runs.

Next to microörganisms, the strength of the flocculated matter is influenced greatest by gelatinous precipitates naturally in the water. Such precipitates probably are largely of organic origin.

Temperature has considerable effect, the strength increasing as the temperature increases. It is neither desirable nor practical to increase the temperature of the water.

The large flocculated particles are built up from small flocculated masses uniting. The binding force of the large masses is not great.

Changes in the chemical treatment may have some influence, but at present we do not know how to modify the treatment to produce a stronger flocculation.

The flocculated turbidity must be very low in the water going to the filter beds when the temperature is low to avoid flocculated matter passing the beds, unless there is something in the water that adds toughness to the flocculated matter.

Consumptive Use of Water by Plant Life

A conference was held under the auspices of the Committee of the Los Angeles Section of the American Society of Civil Engineers on contributions to ground water supplies from rainfall and by spreading of streams, at Los Angeles, March 27, 1928, and at San Bernardino, March 29. Mr. A. L. Sonderegger, Consulting Engineer, was chairman of the committee.

The purpose of the conference was to discuss and determine the research work being done and necessary to permit of a more complete control of consumptive use of water by plants. A reduction in the consumptive use would make a direct benefit to water supply by a decrease in the duty of water, giving water sheds a greater yield. The transpiration and evaporation losses by the forest cover consumes from 40 per cent to 100 per cent of the rainfall. The water supply which is available at the mouths of the canyons is therefore, at best 60 per cent of the rainfall and may be as little as nothing.

The average attendance of the conference was about 100. Addresses and discussions were made by representatives of the Division of Agricultural Engineering, of the U. S. Department of Agriculture, U. S. Forest Service, California State Board of Forestry, Faculty of the University of California, Office of the State Engineer, Consulting Engineers, Foresters and Agriculturists.

The work of the conference was segregated into three activities:

1. Statements of research workers relative to the status of their investigations, their aims and purposes, and the methods applied.

2. Statements by engineers, foresters and agriculturists, as to the need of information for controlling the production and use of water by plant life.

3. Formation of a permanent organization to stimulate research, to assist in securing funds for such research, and to act as a clearing house between research workers and practicing engineers and agriculturists, for data developed.

The conference developed that a great deal of experimental work is being done by the agriculturists and engineers of the U. S. Department of Agriculture, and of the University of California. It was also learned that the California Forestry Experiment Station and the Forestry Division of the University of California are carrying on intensive experimental work in relation to influence of forest cover on run-off, erosion and allied factors.

March 29, 1930, was spent in a field inspection of the work being done by the Division of Agricultural Engineering on the penetration of rainfall north of San Bernardino, and by the California Forestry Experiment Station on the influence of forest cover at their station in Devil Canyon north of San Bernardino. Spreading works at the mouth of Lytle Creek and Santa Ana Canyon were also visited.

The conference adopted resolutions favoring the formation of a permanent organization under the American Society of Civil Engineers and recommended that research work in the use of water by plant life, and consumption of rainfall be specifically included in the water resource studies of the State Department of Public Works, and by various Federal agencies, and that efforts be made to have the necessary funds made available to the various agencies.

Water Works Operations at St. Paul, Minn.—The following note is extracted from the recently issued annual report of the Board of Water Commissioners of St. Paul, Minn.:

"The year 1929 represents in many ways the largest year in the department's history. While the year was not particularly dry, being but 2.79 in. below normal in rainfall, more water was filtered than any previous year, with but one exception. The total revenue for the same year was $981,753.38. The total operating income was $517,231.90; the total gross income $587,808.34; fixed charges paid by the department were $461,868.55, leaving a net income or operating profit for 1929 of $125,939.79. Fixed charges represent nearly 52 per cent of the entire cost of producing water. While this large increase in the net operating profit is due in part to an increase in revenues and a decrease of approximately $15,000 in the fixed charges, there has also been a decrease in the operating expenses of the department."

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor
Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

Sewage Disposal Works of Plainfield, N. J.

While the Plainfield plant has been so frequently referred to during the past ten years in literature on experimental work and while the main part of the plant has been in operation for 15 years I am reminded by frequent inquiries that the plant itself has never been adequately described.

The Plainfield plant, as it is generally called, is really a joint proposition owned and operated by the City of Plainfield and the Boroughs of North Plainfield and Dunellen, under the lengthy, if not enlightening, official title, "The Joint Meeting of the Inhabitants of the City of Plainfield, the Borough of North Plainfield and the Borough of Dunellen." Note the entire absence of any reference to sewage in this voluble corporate name.

This plant was designed on the basis of 40,000 persons contributing 100 gal. per capita or a total of 4,000,000 gal. daily. Metering has cut down the use of water so that the present flow is but 3,500,000 gal. daily although the population exceeds somewhat the 40,000 persons for which the plant was designed. Storm-water is not included and the sewage contains very little trade waste.

The sewage reaches the plant from the collecting systems of the individual municipalities by means of about three miles of 42-in. concrete conduit, which was poured in place, and two pairs of twin 20-in. cast iron inverted siphons to carry the line twice under Green Brook. These siphons are 2,400 ft. and 1,300 ft. long. Considered a part of the joint project, also, is 4,600 ft. of 6-in. cast iron force main to carry Dunellen sewage from its pumping plant to the 42-in. trunk line. The 42-in. trunk line is laid on a grade of 0.5 ft. per 1,000 ft.

Original Design.—As originally designed and built the plant consisted of:

Six Imhoff tanks, 60x25 in plan and 21 ft. deep to the bottom of the hopper, and having two rows of hoppers, five in each row. Centered over each row of hoppers are the gas vents 22 in. wide extending the full length of the tank.

Two 24-in. Miller siphons each entirely independent of the other but receiving the settling tank effluent from a common source, and passing the sewage on to the sprinkling filters.

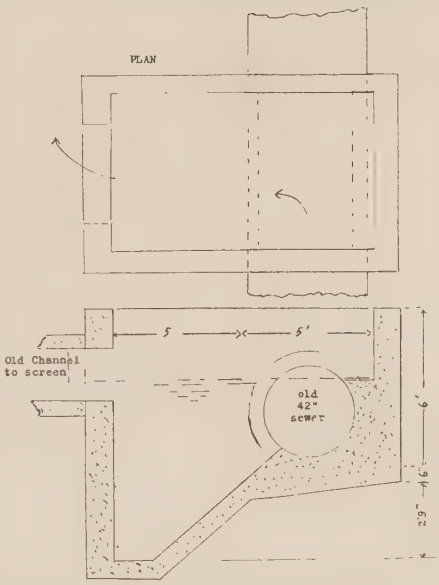


Fig. 1—Plan and Cross Section of Grit Chamber

Two sprinkling filters forced by separate nozzle distributing systems from the two siphons but having no dividing wall; they have a total area of 1.78 acres and are 6 ft. deep.

One final settling tank 97x25 ft. in plan and with a maximum depth of 15 ft. 9 in. below flow line. This tank has Imhoff baffles and traps but a negligible storage space for sludge, it having been the intent to pump the fresh solids back to the preliminary tanks for digestion.

Five sludge drying beds each 84x32 ft. equaling a total of 13,440 sq. ft. Early difficulties with the operation of the Imhoff tanks lead to the installation of a Reinsch-Wurl fine screen of 10-ft. diameter.

While the fine screen assisted considerably in keeping the Imhoff tanks under control, it did not by any means eliminate our troubles in that direction and after various experiments aiming to improve the distribution of solids in the Imhoff tanks and the complete remodeling of one such tank to give a greater proportion of digestion space as compared with the sedimentation space (see Pro. A. S. C. E., Vol. 88, P. 508), the use of two story tanks was abandoned in favor of separate digestion of the sludge under floating, safety covers.

Still later, provision was made for partial aeration of the sedimentation tank effluent for control of odors and later on the use of chlorine was added to this feature.

The following, then, is a complete description of the plant as operated today:

Grit Chamber.—The sewage first enters the grit chamber (Fig. 1), a concrete structure 6 ft. by 9 ft. in plan and 6 ft. deep at the entrance, sloping down to a depth of 9 ft. at the outlet.

This structure is set at right angles to the original 42-in. inlet line between which and a branch channel leading to the screen, it forms a connecting link. The peculiar transverse section is due to the necessity of fitting the chamber between these two channels and to the fact that it was built around the 42-in. inlet line, part of which was afterwards cut away. The steep slope of the bottom provides a hopper for the collection of the deposited material. From this hopper the deposit is raised by air lift to a trough above the flow line where much of the organic matter is removed by washing and the grit is shoveled into wheelbarrows.

Since the purpose of this grit chamber is to remove the maximum proportion of grit from the sewage, and since the accomplishment of this aim is not compatible with simultaneous segregation of grit and organic matter, under the widely varying flows encountered in sewage, it was decided to accomplish the primary purpose by making the chamber of ample proportions to meet the maximum flow and to separate the organic matter by auxiliary washing when the deposit was removed. This washing is done by delivering a constant flow of the deposits, suspended in water, to a trough of uniform cross section. Under these conditions segregation is simple. The deposits are removed and sent through the washing trough daily. An average of 6 cu. ft. of grit is removed each day from 3,500,000 gal. of sewage.

From the grit chamber the sewage flows to the Reinsch-Wurl screen. This screen is 10 ft. in diameter and the slots are $\frac{1}{16}$x2 in. This type of screen

Fig. 2—Floating Cover in Place; Sprinkling Filters in Background

is so familiar that no further description would seem necessary.

As at first installed the screen was equipped with a variable speed motor. The cost of keeping the variable speed control in working order was greater than the saving in current by slowing the screen down during low flows. For a number of years now the screen has been run at a constant speed of 1 rpm.

The original screen plates are still in use after 11 years. The brushes wear from six to nine months.

This screen removes approximately 48 cu. ft. of screenings daily. The screenings contain 88 per cent moisture and weigh 63 lb. per cubic foot.

Plain Settling Tanks.—From the screen the sewage flows to the settling tanks. There are two of these in use, each 25x60 ft. in plan. One has Imhoff baffles which make the effective settling depth problematical—somewhere between 3 and 6 ft.—while from the other all Imhoff baffles have been removed, giving an effective depth of 11 ft. Below this depth, which was the position of the old Imhoff slots, steep hopper bottoms are provided for removal of sludge to the sludge sump.

Both tanks are used as straight settling tanks. The removal of the old baffles not only greatly increases the effective space but reduces the effort necessary to care for the tank. The baffles will be removed from the second tank as soon as possible.

Two 24-in. Miller siphons pass the flow along to the sprinkling filters. The two siphons are entirely independent of each other, each supplying one-half the sprinkling filter area.

Sprinkling Filters.—The sprinkling filters cover an area of 1.78 acres and are 6 ft. in depth. The media is 1½-in. to 2-in. trap rock. The underdrainage is provided by half 6-in. tiles imbedded in the surface of the 6-in. floor on 10½-in. centers. The distribution system is just under the surface with the nozzle base flush with the surface of the stone. Pipe galleries, quarter way in from the sides of the area, carry the distributing main and beneath this the effluent collecting channel. Round Taylor spray nozzles are set on 12-ft. centers.

The sprinkling filter effluent is re-settled in a tank of the Imhoff type. This tank has very little capacity in the compartment below the slots, it having been the intention to pump the solids back to the preliminary Imhoff tanks for digestion.

A 4-in. single Marlow Mud Hog pump, electrically driven, is now hooked up to this final settling tank so that the solids can be sent to any of three sets of drying beds, a special digestion tank near the final tank, back to the preliminary Imhoff tanks, into the plant influent or to the three main digestion tanks.

Sludge Treatment.—From the settling tanks sludge is carried by means of 8-in. cast iron pipe to a sludge sump from which a gasoline driven single 4-in. Mud Hog pumps it to the three digestors.

The digestors are 16 sided tanks 20 ft. deep; two are 38 ft. in diameter and the third is 40 ft. in diameter. They are now practically buried in embankment as protection against cold, but previous to the past winter anywhere from 5 to 12 ft. of the depth has been exposed above ground. Digestion is completed in 40 days at 70° F.

Each tank is provided with a wooden safety floating cover so that the gas can be made available for heating and for power. Fig. 2 shows one of these covers in place and the sprinkling filters in the background, while Fig. 3 shows the covers being constructed. In this photograph the heating coils of the digestion tank supported on small concrete piers are plainly visible. (Note that after the structure had been suitably stiffened, the nest of rafters was cut away from the center so as to leave the base of the 5-ft. gas dome unobstructed.)

Digesting sludge odors are effectively eliminated by this gas collection. Odors at the sprinkler nozzles are cared for either by chlorination or by aerating part of the settled sewage. The aeration plant consists of three Connersville blowers of 370 cu. ft. per minute capacity each, direct connected to three LeRoi gasoline motors rated at 10 to 15 hp. at speeds ranging from 800 to 1,200 rpm.

While these motors are designed to work on gasoline they run very well on the sewer gas collected by the floating covers from the digestion tanks.

The aerating unit is an Imhoff tank in which the old vertical sludge pipes are used as uptake wells in an air lift system. The liquid, sludge and air are drawn up through this uptake pipe and splashed on an apron near the top of the old gas vents, thence tangentially across the surface of the liquid in the former settling compartments, down through the Imhoff slots and back to the bottom of the uptake pipe. Little power is required since the actual lift is from 7 to 9 in.

For further odor control a Paradon

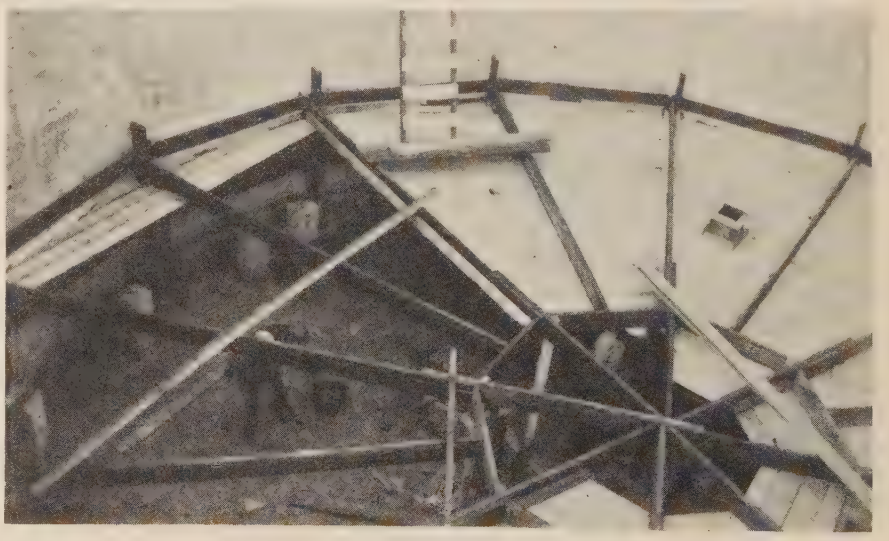


Fig. 3—Floating Cover Under Construction

dry feed chlorinator has been installed to treat the settling tank effluent before it goes to the dosing tanks.

Two convenient methods of dry chlorine application have been used at this plant. When the aerator is working the chlorine can be conveniently applied at the base of the air lift uptake well, taking advantage of the velocity of the liquid rising in this column for mixing purposes. When the aerator is not working the chlorine is applied through a new type of hydraulic diffusor using only 2 gal. of water per minute at a pressure of 45 lb. to secure the required velocity at the point of application. The point of application in this case being in the channel leading from the settling tanks to the dosing tanks.

Sludge Drying Beds.—To the original 13,440 sq. ft. of sludge drying area there has been added 19,600 sq. ft. now used for the digested preliminary sedimentation sludge; and 10,000 sq. ft. used for final tank sludge. This final tank sludge can, however, be put on the area ordinarily used for preliminary sludge as occasion may demand.

The beds are of the open type and are drained by means of open joint tile pipe on 10-ft. centers. Floors are sloped to the drains. Of the several specifications for forming the draining beds the most effective has been to level off over the sloping floors with 1-in. to 2-in. crushed stone, place upon this 5 in. of ¼-in. to 1-in. crushed stone, then 2 in. of ⅛-in. to ¼-in. and finally a very thin layer of sand. Each time the bed is used just enough sand is spread to make the sludge part easily from the fine surface stone.

Sterilization of Water Mains

Use of Portable Chlorinator in Syracuse, N. Y.

By ELON P. STEWART

Division Engineer, Bureau of Water, Syracuse, N. Y.

THE city of Syracuse is extremely fortunate in having one of the purest water supplies in its natural state in the United States.

In spite of this favorable condition, however, the watershed of Skaneateles Lake, which is the source of the supply, is systematically patrolled and pollution kept at a minimum. Moreover, the supply to the city is chlorinated as it leaves the lake as a further safeguard against possible pollution.

The campaign against cross-connections in 1926 and 27, however, brought to the minds of the officials of the Water Supply Division that, while they were using every precaution to safeguard the water supply at its source, there was still considerable danger of pollution after the water had reached the distribution system. Cross-connections were therefore eliminated and attention then turned to the possibilities of pollution due to polluted surface water entering mains where breaks occur at places where the soil is of questionable sanitary nature, and to pollution in new mains where the pipe lays on the ground for some time before it is installed in the ground, subject to street pollution.

This possible source of pollution was brought more favorably to mind in 1928 when a break occurred in a small water main in a section of the city where a fill had been made of ashes and other trash. On turning on the water after repairs were made, it was found that considerable debris had washed back into the broken main while repairs were being made. While no pollution resulted from this experience, it was readily seen that had polluted material been present, the water in that section might have been contaminated.

As portable chlorinators were then available on the market, such an apparatus was purchased and has been used by the Water Division since that time.

When breaks occur now in sections of the city which are subject to ground water of a questionable sanitary quality, or where the fill is of the same nature, a tap is made on the main after repairs have been made and liquid chlorine is introduced into the main as the water is turned on. The boundary valves surrounding the break are kept closed and a hydrant opened, and a suitable flow maintained until the entire section of main within this boundary has been thoroughly chlorinated. The mains are then flushed out with clean water and put back into service.

As a portable chlorinator is especially designed for low rates of application, with a little experience, the operator can easily apply and control a dose of chlorine which will adequately sterilize the main in question.

Tests for residual chlorine are made at the hydrant through which the chlorinated water is expelled from the mains. For this work, a residual of two to four parts per million is maintained after the chlorine has had a 10-minute contact with the water.

The same method of sterilization is used when new mains are put into service, where the pipes have laid for some time on the street prior to installation. In this case, they are apt to be coated with germ laden dust from the streets.

The accompanying illustration shows the portable chlorinator set up inside of the standpipe at Woodland Reservoir preparatory to sterilizing the bottom of this standpipe after cleaning. Several inches of highly chlorinated water were introduced into this standpipe to accomplish this result.

As the chlorinator is compact and easily carried about by two men or by a light truck or car, it is an easy matter to sterilize mains, standpipes or small brooks on the watershed on a few minutes' notice.

It is felt that this piece of equipment has added a real factor of safety to the protection of the water supply of the city of Syracuse.

Photo Courtesy Paradon Mfg. Co., Arlington, N. J.

Portable Chlorinator Set Up Inside Standpipe Preparatory to Sterilizing the Bottom After Cleaning

Nineteen New City Manager Cities in 1929:—Nineteen cities adopted the city manager plan in 1929, the largest one being Flint, Mich., with a population of 180,000. Michigan leads in the number of city manager cities with 44, while Florida has 38, Texas 32, and California 31.

Gyroscopic Precession as the Cause of the Migration of Cyclonic Storms

By HALBERT P. GILLETTE

IN several articles I have shown how free electrons in the air produce cyclonic storms because they are caused to rotate about magnetic lines of force. Once set in motion in this manner the electrons become electromagnets, and they attract to themselves other electrons moving in the same direction, thus building up and intensifying the whirl-belt. But since electrons in opposite sides of such a whirl-belt repel one another, the whirl-belt ultimately expands until it brings about its own destruction, aided, of course, by friction. The free electrons in such whirl-belts attract molecules of air, but their impacts upon air molecules also generate an air whirl.

Small whirl-belts of this sort often originate in the great permanent cyclonic whirl-belts, of which the two best known, are the Aleutian whirl and the Icelandic whirl. These small whirls break away from the great parent whirls and travel in a southeasterly direction. That is the direction in which the southern halves of these two great whirls are rotating, and while their centrifugal force may account for the initial impulse that starts the small whirls on their migration eastward, it is not sufficient to explain their maintenance of a forward velocity of 30 miles an hour, or more, for thousands of miles from their place of origin. At least one cyclonic storm has been known to travel clear around the earth, and perhaps this is a more common occurrence than has been supposed. What, then, is the propelling force?

The books tell us that these cyclonic storms are carried by the general air currents, but laying aside the objection that a general air current in an easterly direction itself calls for a better explanation than the books give, there is the great objection that the forward velocity of a cyclonic storm is often much greater than that of the general air current, if we may judge by the velocity of clouds that are presumably drifting with the air. Often when the air in general is almost still, a local cyclonic storm springs up as if from nothing, and goes scurrying away at express train speed. No, the hypothesis that cyclonic storms are carried along by general air currents is untenable; indeed, even more unsatisfactory than the far-fetched explanation of the rotary motion of cyclonic storms as being due to changes in centrifugal force as the air moves to lower latitudes. How about the rotary motion of the permanent cyclones near Alaska and Iceland? They do not migrate, but they rotate; and we have yet to see any explanation of their rotation that can not be shown to be unsound, except the explanation that they are whirled electromagnetically.

The eastward migration of cyclonic storms from those great permanent cyclones, and indeed, all cyclonic migrations, may be explained by the precession principle of the gyroscopic top, if we substitute electromagnetic force for gravitative force. This principle is stated by Russell (Astronomy, 144) thus: "Any force tending to change the direction of the axis of a whirling body produces a motion exactly at right angles to its own direction." By aid of this gyroscopic principle, the motion of the earth's axis so that it describes a cone, and the consequent "precession of the equinoxes" are explained.

If we regard each cyclonic storm as a magnetic top spinning about an axis, there is no difficulty in understanding why the top travels in an easterly direction around the magnetic pole; for it is obvious that the earth's magnetic pull on this magnetic top can not be equal at all points of its axis, and must therefore tend to tilt it. But the instant that such a tilt tends to occur in a spinning body, it begins to move at right angles to the direction of the tilting force. This gyroscopic principle is commonly illustrated by gravity acting as the tilting force, but a magnetic force can be used instead, and nature evidently furnishes examples of such use in the propulsion of whirling air charged with electrons.

The gyroscopic character of the forward motion of cyclonic storms has been concealed, primarily because their magnetic nature was not perceived, and secondarily because cyclonic tracks or paths often differ greatly from one another. Nevertheless Kullmer discerned that storm tracks across North America and the Atlantic have a tendency to be arcs whose center is the magnetic north pole. But this important discovery was not followed up by any explanation of its cause. It is more nearly true to say that storm centers originating in the Aleutian "low" often tend to follow a track that is approximately perpendicular to the isogonals or lines of equal magnetic declination.

This is only a crude outline of a general tendency, but its existence is evidence of magnetic control of storm tracks.

Until I discovered the existence of magnetic whirl centers near the equator, I was greatly puzzled by the tracks of tropical hurricanes or typhoons. The two regions where this type of cyclonic storm is most prevalent are just north of South America (the West Indian region) and just north of Australia (the Philippine region). These hurricanes usually start in a northwesterly direction, but soon veer to a northeasterly direction, describing tracks that are often almost perfect parabolas. Near each of these regions I have found a magnetic whirl that is clearly disclosed by circular arcs of land, just as the Aleutian whirl is disclosed by the perfect circular arc of the Alaskan Peninsula and the Aleutian Islands. The entire northern and northwestern coast of South America lies on such a circular arc. So do Sumatra, Java and a long string of islands north of Australia. There are 12 such magnetic whirls on the globe. The magnetic north pole lies midway between two of them and the magnetic south pole midway between two others. The equatorial whirls of air that correspond to the molten whirls reverse their direction every six months. This explains the semi-annual reversal of the monsoons of India and of Central America. I will not discuss the cause of these reversals now, merely stating that it is an electromagnetic phenomenon depending upon the relative positions of the magnetic axes of the earth and sun.

The South American magnetic whirl controls the initial direction of gyroscopic precession of the hurricanes of the West Indian region, but when they reach higher latitudes the Aleutian and Icelandic magnetic whirls, and the general magnetic field of the earth, preponderate, and turn the storms northeasterly. A similar phenomenon occurs in the Philippine region; but in that part of the world there are three magnetic whirl centers not far apart in longitude, namely those of (1) Australia, (2) the Philippine Islands and (3) Japan.

Judging by their effects, the 12 magnetic whirl-belts, both in the atmosphere and in the molten interior of the earth, are neither constant in diameter nor in magnetic strength, both of which are affected by the sun's varying magnetic effect on the earth and that of every one of the visible planets, not to mention at least three invisible planets of great magnetic power. Given the resulting variability of magnetic power of these 12 whirl-belts, and of the Heaviside layer, and of the indidividual cyclonic storms, it follows that great regularity in the tracks of storms should not be looked for.

Since the anticyclones that cause barometric "highs" rotate in a direction opposite to that of the cyclones that cause the "lows," it might be ob-

jected to our magnetic theory of storm propulsion that the anticyclones should move westerly, whereas they move easterly in the higher latitudes. The answer is that every anticyclone is the tail of a cyclone, to which it is bound by electromagnetic attraction. In fact a cyclone and its anticyclonic mate are the two legs of a horseshoe magnet whose curved part is usually miles above the earth. The cyclonic end is the more powerful magnetically, both because it contains more electrons and because it is less expanded. Occasionally the anticyclonic end of such a horseshoe magnet never reaches the earth, for it becomes dissipated. Then we have only a cyclonic whirl near the earth, and are misled into thinking that no accompanying anticyclone exists.

Although the anticyclonic "tail" of a great air whirl must follow the cyclonic "dog," it can wag and it usually does wag. That is why anticyclones often follow cyclones, but not in the same path. Being of opposite polarity to its cylonic mate, an anticyclone is differently affected by the magnetic fields of the earth, and does not behave exactly like its mate. Remember that not only are these two legs of these horseshoe magnets of the air very flexible, but that the arched part of the middle also is flexible, so that the two ends can separate or approach one another. To this flexibility and the frequent difference as to the tracks of these pairs, I attribute the failure of meteorologists to see that cyclones and anticyclones go in pairs that are interconnected, being indeed opposite ends of one rotating mass of air that is bent into a U-shape. That this is the case was suggested to me by the fact that sunspots go in pairs of opposite polarity that cannot be well explained except by assuming them to be the opposite ends of a U-shaped whirl of gas. Then I reasoned that each of the great permanent cyclones on this earth should have a mate in the form of an anticyclone. Turning to a chart, I found the anticyclonic mates of the Aleutian and the Icelandic permanent cyclones, far to the south. I had previously discovered three magnetic whirl centers around the arctic circle, the third one being in Siberia, so I looked for its permanent anticyclonic mate far to the south, and found it on the chart. Since I had found evidence of three similar magnetic whirl centers around the antarctic circle, I looked for three permanent anticyclones far to the north of them, and found all three on the chart in about the expected positions. Several forecasts from a theory that result, as these forecasts did, in confirmation by an appeal to the facts, leave little doubt as to the correctness of the theory.

It matters not to the forecaster whether he must himself experiment to secure the facts, or whether he must wait for nature to produce them, or whether he must search scientific literature to find record of them, for the test of the truth of a theory is its agreement with facts that were not used in framing the theory. A true theory leads to correct inferences, and it is immaterial whether their correctness is determined by ancient history, by present happenings or by events yet to happen. Of course it is more spectacular to "predict forward" and to have the prediction verified years later, as when Halley foretold the date of return of his comet; but it is just as good a test of a theory to use it to "predict backward" and to find that facts already published, but unknown to the prophet, verify his prediction.

Predicting backward, as we like to designate this sort of inference from a theory, has one supreme merit: You need not wait till 17 years after death, as did Halley, to have posterity pat your "shade" on the back and proclaim you a good prophet.

Water-Works Improvements for Cleveland, Ohio

Water-works improvements for the city of Cleveland, Ohio, aggregating a total expenditure of some $60,000,000, are being studied by a board of three engineers, consisting of L. R. Howson, of Alvord, Burdick & Howson, Chicago, Ill.; James H. Herron, Cleveland, and Robert Hoffman, city engineer of Cleveland. The work to be constructed in the immediate future will consist of a 6-mile tunnel into Lake Erie, an additional 100-m.g. filtration plant and 24 to 60-in. mains. The study will also include an analysis of the rate structure which will produce a revenue sufficient to carry the expenditure.

Another very interesting phase of the study concerns a special raw-water supply for industries. The Cleveland steel industries are largely situated on the Cuyahoga River and require large quantities of water, at the present time about 500 m.g. per day being used by these industries alone. The minimum flow of the river is approximately 50 cu. ft. per second, so that during the summer period the water is used over and over as many as fifteen times in its course down the river. The industries on the lower part of the river, of course, get a very hot water, not well suited to the purposes for which it is used. This has given rise to the study of a separate raw-water supply through the construction of a large tunnel to the lake and the construction of shafts on the tunnel at the various industries. Practically all of the major industries have waste blast-furnace gas with which they can do and are now doing their pumping at an exceedingly low cost.

The engineering commission has been at work for some weeks. It hopes to complete this investigation and report some time in May.

Exhibitors at 50th Annual Convention A. W. W. A.

The following is a list of applications for exhibit space at the 50th annual convention of the American Water Works Association, St. Louis, Mo., June 2-6:

Pittsburgh Equitable Meter Co.
Water Works Engineering.
The American City Magazine.
Rensselaer Valve Co.
National Water Main Cleaning Co.
R. D. Wood & Co.
Lock Joint Pipe Co.
Gamon Meter Co.
The Leadite Co.
Bingham & Taylor Corp.
Ross Valve Mfg. Co., Inc.
Neptune Meter Co.
The American Rolling Mill Co.
Paradon Mfg. Co.
Wailes-Dove-Hermiston Corp.
Builders Iron Foundry.
The A. P. Smith Mfg. Co.
H. W. Clark Co.
Buffalo Meter Co.
National Tube Co.
The Central Foundry Co.
Public Works (Journal).
Chicago Bridge & Iron Works.
The American Brass Co.
Wallace & Tiernan Co., Inc.
Michigan Valve & Foundry Co.
Columbian Iron Works.
Waterous Co.
McWane Cast Iron Pipe Co.
Hays Manufacturing Co.
Vogt Bros. Mfg. Co.
Gillette Publishing Co.
United States Pipe & Foundry Co.
Eddy Valve Co.
Hydraulic Development Co.
Iowa Valve Co.
Worthington Pump & Machinery Corp.
East Jersey Pipe Co.
De Laval Steam Turbine Co.
The Pitometer Co.
Pittsburgh-Des Moines Steel Co.
International Filter Co.
Mueller Co., Inc.
Fairbanks, Morse & Co.
Engineering News-Record.
National Meter Co.
Ludlow Valve Mfg. Co.
Ford Meter Box Co.
Badger Meter Mfg. Co.
Hersey Manufacturing Co.
R. W. Sparling.
W. & L. E. Gurley.
American Cast Iron Pipe Co.
The Atlas Mineral Products Co. of Pennsylvania.
The Kennedy Valve Mfg. Co.
Joseph G. Pollard Co., Inc.
Edson Manufacturing Corp.
Johns-Manville Corp.
Lead Lined Iron Pipe Co.
The Dorr Co.
National Cast Iron Pipe Co.
Omega Machine Co.
Automatic Cone Valve Co.
Barber-Greene Co.
Layne & Bowler Co.

Pre-Chlorination of Filters

How Pre-Chlorination at Newburgh, N. Y., Improved Filter Runs and Color Removal and Lowered Wash Water Consumption

By JOHN F. KINGSLEY
Chemist, City Board of Health, Newburgh, N. Y.

THE city of Newburgh, N. Y., is supplied with filtered water from two impounding reservoirs. The filter plant is a modern one of the rapid sand type. The plant was built in 1923 and has a designed capacity of 5.0 m.g.d. The average daily consumption is about 4.0 m.g.d. The water treatment consists of coagulation with aluminum sulphate, aeration of the dosed water, two hours' period of sedimentation, filtration and chlorination. Until lately, the chlorine was applied only to the filtered water as a single dose.

Character of the Raw Water Supply.—The raw water is a fairly soft water of low turbidity and moderate color. The natural alkalinity is sufficient for reaction with the alum, so that this chemical alone is employed to secure "floc." Microscopic organisms have given the chief trouble in treating the supply. With the advent of warm weather in the spring, Asterionella makes its appearance and can become quite troublesome unless controlled with copper sulphate at the reservoirs. The hotter summer months bring profuse growths of Anabaena. Here again the copper sulphate treatment has been resorted to. The spring is also a time of trial due to the heavy infestation of small Crustacea, Cyclops predominating. Copper sulphate treatment has had no effect upon these animal organisms, and we have been compelled to suffer their presence until nature offered relief.

Condition of the Filters.—During periods of active algae growth in the reservoirs the filter beds have been subject to severe surface cracking. Mud balls and wide wall cracks were always attendant and presented a serious and distressing problem which was progressively increasing. At that time we were using the conventional 24-in. vertical rise wash water velocity. As the trouble increased it was observed that the wash water breaking over the troughs did not seem to carry over the usual amount of accumulum and finally came over clean much sooner than usual. Examination of the sand after such washes revealed, as might be expected, that the sand was far from clean. The coating on the grains was as bad as before the wash. Mud balls were very large, some averaging 3 in. in diameter, and were well distributed both horizontally and vertically.

When such a situation presented itself we were forced to treat the filters with caustic soda. We employed the flake chemical and scattered it over the surface of the sand in such amounts that with 1 ft. of water over the sand, the concentration would be about 1 per cent. After the chemical had been dissolved it was thoroughly distributed by stirring with paddles. The caustic solution was then drawn down into the sand by means of the rewash valve, and left in contact with the sand over night. The bed was washed next morning to get rid of the chemical. A second and more prolonged washing was resorted to in order that the loosened sand coating might be scrubbed out. This procedure remedied the trouble but we realized that it was only a relief and that it would have to be repeated regularly unless other steps were taken to prevent the progressive accumulation in the sand.

Experience with Pre-chlorination.—Upon recommendation of Mr. Wellington Donaldson of Fuller & McClintock, Consulting Engineers, New York, N. Y., we started to chlorinate the raw water in August, 1929, and, in addition to the customary effluent chlorination, are still continuing it at this writing. We hoped that the chlorine would control the periodic filter clogging by algae and prevent the formation of the slimy material on the filter walls and sand grains.

To date we are delighted with the results secured. Although it is possibly too early to state that pre-chlorination as practiced at Newburgh will take care of all conditions throughout the year, we are inclined to believe that our particular filter problem has been solved.

The surface and wall cracking has been completely eliminated. When the bed is drained previous to washing, the sand presents a smooth and unbroken surface. It is tight against the filter walls and covered uniformly with a thin layer of coagulum. Under this, which can be demonstrated by scraping away the top layer, the sand is very clean and sharp. Mud ball formation has been very materially lessened and those few that do occur are very small. When a bed is drained down for inspection, after a wash the sand is like clean beach sand. The method of washing remains the same as before pre-chlorination; that is, there has been no increase in velocity or the amount of wash water applied at each wash.

Filter runs have not materially increased over the best runs secured before pre-chlorination. We have, however, to date averaged 20 hours and we have not experienced the former periods of very short runs, which have made it difficult to meet the demand for filtered water.

The effect on the filter walls and troughs has been most gratifying. Concrete work has the appearance of being much cleaner than previously. The slime coating is much lessened and what there is of it is soft, non-adhesive and may easily be washed off with a small garden hose. This advantage has added materially to the good impression made upon our visitors, of which we have a goodly number. The effect of an otherwise clean and sparkling plant is lost when the visitor is introduced to dirty and dingy looking filters.

Another and incidental advantage of pre-chlorination has been the improved color removal. Previously the average color of the filtered water was about 10 p.p.m. to 12 p.p.m. With the same coagulant dose and other factors the same, such as basin retention time and rate of filtration, we now secure a filtrate that averages between 3 and 8 p.p.m., and for the most part below 5.

Bacterial removal has also been increased as might be expected. The average bacterial count in the filtered water on agar at 31.5° C. for a representative period before pre-chlorination was 8.3 per c.c. as against 0.5 for a corresponding period at this time.

Chlorine Doses.—When the experiment was first started we attemped to dose the raw water to such an extent that a residual of 0.10 p.p.m. could be detected in the water as it passed through the filters. Accordingly the raw water dose was set at 6 lb. per m.g. It was soon apparent that such a dose was entirely insufficient to produce the desired results. We then raised the raw water dose step by step until the gas was being fed into the raw water at a rate of 12 lb. per m.g. Even with this rather high dose we were able to detect only a trace of residual chlorine in the filter effluents. For some time while using these higher doses we were in reecipt of growing complaints as to tastes and odors in the water. That the tastes were not ones of chlorine but rather of a "musty" or "woody" flavor, is testified to by our own taste sensations as well as that of many of the consumers. It was then apparent that the tastes and odors were due to chlorine substitution or additional products with the organic material in the raw water, and that some of the methods of de-chlorination would

have to be employed if we were to produce a tasteless water. As our plant is not equipped for such treatment we were forced to lower the raw water dose till the tastes and odors disappeared. We found that a chlorine dose which left just a detectable trace of residual in the water as applied to the filters gave us a finished water which was free from all odors and tastes.

At present we are employing a 3 lb. per m.g. dose. This is of course necessarily governed by the chlorine demand of the raw water and retention time in the basins. Our point of application is not very advantageous, it being after the alum dose and before the water reaches the aerator. This is of course wasteful of chlrine, but for the experiment we decided that it would be more economical to waste a portion of the gas than to go to the expense necessary to provide for a permanent point of application after aeration.

It is estimated that from 25 to 35 per cent of the chlorine gas is wasted in this manner. From this it would seem that under permanent conditions it would be necessary to use only a little more than 2 lb. per m.g. to leave the desired residual on top of the filters. With the chlorine demand of the raw water satisfied or nearly so, it is necessary to apply only from 1.5 to 2 lb. per m.g. to the clear well to maintain a residual of 0.10 p.p.m. ten minutes after application, as desired by the New York State Department of Health. Therefore little if any increase in operating costs is to be expected by the adoption of pre-chlorination at our plant, since a saving of the materials and labor necessary to treat the filters with caustic soda will be effected.

The following table will show at a glance the improvement in filter runs and color removal and the lower wash water consumption:

	August to April, 1928			August to April, 1930		
	Filter runs, Hours	Color Filter, p.p.m.	Per Cent Wash Water	Filter Runs, Hours	Color Filter	Per Cent Wash Water
Maximum	24.5	17	4.3	28.2	9	3.2
Minimum	4.5	5	2.4	16.0	3	1.6
Average	18.3	9.5	3.3	21.3	5	2.6

Conclusions.—Pre-chlorination of the raw water at Newburgh, N. Y., has accomplished several beneficial results, and without any significant increase in cost of operation, as follows:

1. Elimination of excessively short filter runs.
2. Reduction in both number and size of mud balls formed.
3. Elimination of surface cracks and wall cracks in the sand bed.
4. Better color removal with no increase in coagulant dose.

It is interesting to note here that the improvement in condition of filters secured by Hulbert and Herring (Jour. A. W. W. A. 21: 1445) at the Detroit Experimental Plant by using excessively high wash water velocities, has been obtained at the Newburgh plant by pre-chlorination of the raw water.

The Newburgh experiences show that pre-chlorination has the additional advantages of effecting a greater color removal than possible with effluent chlorination alone, and of being able to prevent short filter runs caused by filter plugging by microscopic organisms. Pre-chlorination is certainly less costly than would be the radical changes in design necessary to adopt the very high velocity wash at many plants. Moreover pre-chlorination is not open to the danger of disturbing the gravel layers as Baylis (Jour. A. W. W. A., 21: 1494) in discussing the Hulbert and Herring paper feared might occur by the use of exceptionally high velocity washes.

Annual Meeting Montana Section American Water Works Association

The 5th annual meeting of the Montana Section, American Water Works Association was held in Missoula April 17, 18 and 19. This meeting was characterized by more enthusiasm and interest than evinced at any previous gathering of the section. Those instrumental in securing and fostering this organization were unanimous in the opinion that the section is now on a sure and permanent footing and will go forward.

President Jack Hinman with his engaging personality and enthusiasm was the big drawing feature of the meeting. He made several speeches in which he showed his comprehensive grasp of the problems confronting the water-works operator and administrator. On Wednesday noon preceding the meeting, Mr. Hinman gave a 10-minute talk over the radio at Great Falls (Station KFBB) on the subject of "The Water Supplies of Cities." The range of the station is practically all of Montana and parts of the adjacent territory.

Emil Sandquist, City Engineer of Havre, President of the Montana Section, presided. Mr. Cortese, Superintendent of the City Water Department, Livingston, Vice-President, conducted the round-table discussions and was otherwise active in the business at hand.

The round-table discussions of the first day were a prominent feature of the meeting. The members of the section have much the same problems as confront the men in such work the country over and entered into the discussions with tales of experiences and methods of solving troubles that produced a volume of invaluable information. This was all taken by a stenographer and will be transcribed in detail, as soon as possible.

The papers called for on the program were all given, often illustrated by charts and photographs which increased their interest.

Trips were taken by the delegates to Bonner to see one of the large saw mills in the district in operation, and to the intake works of the local water supply system. At the latter place lunch was served by the Montana Power Co., owners and operators of the water utility in Missoula.

Mr. Christensen, manager of the Missoula branch of the Montana Power Co., was a genial host. He has been a member of the A. W. W. A. since 1919. Mr. Thane, superintendent of the water department of this company, took the brunt of the local arrangements and did his work so thoroughly that never a hitch occurred in the proceedings. All past presidents of the Montana Section were on hand.

The registration list shows 58 names. Other local men visited the meetings from time to time.

The new officers for the ensuing year are:

Mr. J. R. Cortese, Superintendent Water Department, Livingston, President.

Mr. H. M. Johnson, Superintendent Water Department, A. C. M. Co., Anaconda, Vice-President.

Mr. Eugene Carroll, Vice-President and General Manager, Butte Water Co., Butte, Director of the A. W. W. A.

Mr. H. B. Foote, Sanitary Engineer, State Board of Health, Helena, Secretary-Treasurer.

Anaconda was selected as the meeting place in 1931.

Motor Vehicles of Los Angeles Water Department.—The Transportation Section of the Division of Water Distribution and Operations of the Department of Water and Power of Los Angeles, Calif., had 528 automobiles and trucks, 29 trailers and 22 pieces of equipment specially mounted on trucks, at the close of the fiscal year ended June 30, 1929. This shows an increase of 16 automobiles and trucks over the preceding year. This addition to the fleet was made necessary, due to the requirements for additional equipment on the Colorado River project, and the land appraisals in the Owens Valley. This fleet of cars traveled 5,419,192 miles, at an operating cost of 8.75 ct. per mile, as compared with 512 cars traveling 5,313,365 miles for the previous year, at an average cost of 9.01 ct. per mile. This represents a saving in total operating cost of .26 of a cent per mile.

Los Angeles Approves $38,800,000 Water Project.—A bond issue of $38,800,000 for the extension of the Los Angeles aqueduct and the acquisition by the city of water rights in Mono basin was approved at a special municipal election May 20 by a large majority.

Water Works and Sewerage

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The Fruitfulness of a Theory As a Test of Its Truth

In recent years it has become somewhat the fashion to regard scientific theories as mental concepts that have no necessary counterparts in nature. Thus regarded a scientific theory is a "convenient fiction," and therefore a sort of mental chameleon that may change its colors at will. The idea is plausible, but somehow it sticks in our mental gullet, and will not down. Karl Pearson in his "Grammar of Science," has done much to foster this conception. In the same book he extols the theory of mathematical probability, and naturally he does this because the scientific specialty upon which his renown rests is Probability. Let us see what happens when we turn his pet probability guns on his pet metaphysical hobby.

With Stanley Jevons he agrees that the truth of every scientific principle is probable by an appeal to mathematical probability. By that test no scientific theory is better established than that atoms unite to produce molecules. Yet neither a molecule nor an atom has ever been seen under the most powerful of microscopes. Hence it is clear that direct visual perception is not a necessary means of establishing the truth of a theory.

A severe test of the truth of any theory is the occurrence of events in close agreement with predictions based on the theory. This test of validity is not questioned by Pearson, nor, we believe, by any scientist of repute.

A third test of the truth of a scientific theory is its fruitfulness in disclosing unexpected relationships or in facilitating the invention of useful devices. This test is really a special case of the second test, for if a theory can be used successfully to predict future events, it must lead to the prediction of events unexpected not only by men in general but by scientists. We know of no exception to the principle that true theories invariably lead to discoveries of facts or relationships previously unsuspected.

Even were an exception to this principle to be found, it would have to be classed as one so rare as to leave enormous odds in favor of the principle. Hence, it follows that an old theory that fails to be fruitful is probably false.

The theory that theories are purely "convenient fictions" (e. g. the atomic theory) is an old one, and of all the theories that have been proposed to explain mental actions we know of none that has been more barren. What discovery has it ever assisted any man to make? Contrast its utter barrenness with the amazing fecundity of the ether theory, and ask yourself which of the two great English scientists is more likely to be correct, Lord Kelvin, a champion of the ether theory, or Karl Pearson whose theory of thinking led him to deny not only the existence of ether but of molecules, atoms and electrons. Pearson lays down a principle to the effect that where sensual perception of an alleged thing is absent only "convenient fictions" exist. Yet his pet theory of probability sinks this alleged principle at the first shot, and leaves it "without trace," for probability proves the truth of the hypothesis that electrons, atoms and molecules exist and disproves his theory about theories.

We suspect that Pearson's early metaphysical readings had so warped his mental vision that he became a subject of the kingdom of Topsyturviana. There have been many such, who, finding it difficult to understand how a mind can perceive external things, solve their difficulties by asserting that it doesn't. The objective world then becomes forever unknowable in any true sense, and only the operations of the mind remain knowable. Such a metaphysician objects when you affirm a certain characteristic of Mr. Smith, and assures you that all you can safely affirm is that your mental picture of Mr. Smith has that characteristic. You are permitted to believe that the photograph of Mr. Smith is the only thing to be reasoned about, but that the real Mr. Smith who sat for that mental photograph can never be understood!

We could not, and should not, condemn an hypothesis of this sort, nonsensical though it seems, provided—mark well the proviso—that it is a fruitful hypothesis. But when, where and by whom was Pearson's hypothesis or theory ever used to disclose a solitary new fact in the entire realm of science?

"The Mayan Mystery"

Not long ago an article in "Saturday Evening Post" described the ruins of a large Mayan city in Yucatan. The author repeatedly expressed doubt as to the possibility of ever ascertaining why that city was abandoned. In a manner characteristic of too many writers of articles of a popular nature he failed to look up what scientists had said upon the subject.

In "The Climatic Factor as Illustrated in America," published 16 years ago, and again in "Climatic Changes," Prof. Ellsworth Huntington presents a convincing theory of the decadence of Mayan civilization in Yucatan. He points out that climates all over the globe have changed periodically, and he produces a mass of evidence to support the theory that there are great cycles of climatic change, which are counterparts of the minor cycles of weather change. The well known sunspot cycle of 11.2 years is shown to be accompanied by marked changes in rainfall, some regions showing a maximum at the very time that others show a minimum. Cycles of vastly greater length are probably of similar nature. Yucatan is one of the regions whose summer rainfall has increased in recent centuries, whereas in California, Arizona and New Mexico the contrary has occurred.

Excessive rainfall in a tropical region results in

jungle growth and in a multiplication of insects and bacteria, often to such an extent as to be fatal to men.

Huntington advances a plausible theory to explain such climatic cycles. At least in part it is probably correct. The author of the "Saturday Evening Post" article promises fame and fortune to him who solves this Mayan mystery. Neither fame nor fortune have yet come to Huntington, as a result of his solution of the mystery, not even enough fame to make his work known to an author, who seemingly has pondered over the mystery until it drove him to write at length about it.

Fame rarely, and fortune never, is the reward for solving such a scientific problem. But let a man be first to fly from New York to Paris, and he is apt to be greeted by Fame, dined by Croesus, and decorated by the governments of the world. Contrast such marks of public appreciation for spectacular intrepidity with the rewards of the scientists and the inventors who gave the flyer his wings, and you will better appreciate the immature development of the minds of the vast majority of men. You will understand the feeling that prompted that very original probability specialist, Arne Fisher, to say in one of his prefaces: "In these departments of knowledge the appreciaton of one's peers is after all the only real reward one can possibly expect." But even there the appreciation is very slow in coming, as Fisher's own experience abundantly demonstrates. A man's scientific peers are usually so absorbed in their own problems that they have scant time to appraise the original discoveries of other men, even in their own realm. Moreover, there is an almost universal spirit of skepticism and even of jealousy that operates against an immediate expression of appreciation by even one in a hundred of one's scientific peers. Einstein, with an air of resignation, once remarked that when he first published his epoch-making theory of relativity, just one man in the whole world of science patted him on the back and uttered a word of approval. Small wonder that he now locks himself behind iron doors and seeks rather the approval of his own mathematics. He turns to Old Man Probability and asks his verdict as to each new theory, and when the old fellow calculates an answer that is favorable, Einstein is content to let the scientists of the world think what they may—or think not at all—about it; knowing that the loss is theirs, not his. The greatest reward to a scientific discoverer is the feeling that his work has not been in vain, and the knowledge that no true scientific theory or discovery has ever failed to be useful to mankind.

A New Type of Scientific Text-Book

Several scientific books have recently appeared that consist entirely of important papers or abstracts thereof, in the language of the original discoverers. There is a twofold merit in this type of book: (1) It tends to arouse in the reader to an admiration for research ability; and (2) it aids him in understanding how research is conducted. From this there flows a greater interest in science, for who is there that is not more interested in knowing how a discovery came to be made than in knowing the nature of the final discovery? If a prospector shows you a nugget that he found in Alaska you may be somewhat interested in its size, shape and physical qualities, but you are vastly more interested in the prospector's story of how he found the nugget.

Our scientific text-books are largely museums in which classified specimens are displayed. There you may examine and come to understand the nature of principles that research genius has discovered; but here is nothing, or next to nothing, about the methods used in making each discovery. If you wish to appreciate the vital distinction between the typical text-book and the original story of each discovery, read any text-book on physics and then read Faraday's "Experimental Researches in Electricity." In the one you have some of Faraday's discoveries expressed in condensed form as laws or principles, dull and uninteresting as a rule. In the other you have a picture of Faraday at work, drawn by his own hand. Let authors tell you till the crack of doom that they have collected and condensed for your use all the most worthwhile principles of their branch of science, but don't believe it. Almost invariably they have failed to present you with the most worthwhile part of the whole story of scientific achievement, namely how the discoverer got his first clue and how he followed it up until he made his great discovery.

If it be argued that life is too short and scientific principles are too numerous to be acquired by the long process of reading the full story of each discovery, then our reply is that education is not acquired by learning facts but by learning how to think, and that of all thinking the most valuable is original thinking. We go further, and insist that even ordinary thinking must be, to some extent, original if it is to be very profitable. Utterly unoriginal thinking exists only in the machine-like operations of the brain, such as is disclosed by instinctive actions. Conscious thinking invariably involves some degree of originality, as may be seen by comparing the differences between two bridges of the same span and load-carrying capacity, designed by two different engineers. No two designs are alike in all respects; and to the extent that one of them differs from a mean or typical design, to that extent is it original.

There are occasions when the most economic procedure is to adopt the typical design, but the very act of reasoning that leads to adopting a standard design often shows originality. Nearly every 2x4 architect seeks to be original, and in doing so displays his lack of originality. Standards are anathema to the slightly original mind that is striving to be very original. He delights in differing, whether the difference be one that adds to beauty or utility, or not. So let us not suppose that training in research and in original thinking generally is a training that only a few gifted individuals should be given. The highly gifted ones are the least of all in need of any training save that to be acquired by reading and by self-instruction. For example, schools and classes contributed almost nothing to the success of that marvelous Scotch mathematician, Colin Maclaurin. "His genius for mathematical learning discovered itself so early as at 12 years of age, when, having accidentally met with a copy of Euclid (geometry) in a friend's chamber, in a few days he became master of the first six books without any assistance; and thence, following his natural bent, made such surprising progress, that very soon after we find him engaged in the most curious and difficult problems. Thus much is certain, that in his 16th year, he had already invented many of the propositions afterwards published under the title of Geometria Organica."

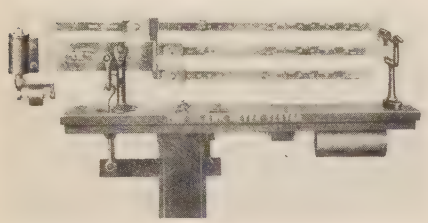
H. P. Gillette

Recent Developments in the Water-Works Field

Improved Devices by H. W. Clark Co.

Devices for the water-works trade brought out by the H. W. Clark Co., Mattoon, Ill., during the last year include a new long-handle key, a scale-beam for water-meter testers, the Klinck test and puddle plug and a line of locked meter-box rings and lids.

Where the long-handle key is used,



Clark Meter-Tester Scale Beam

the meter boxes are placed in a straight line in the parkway as close to the sidewalk as practicable. The meter reader inserts the end of the key in a hole in the lid of the meter box. A twist of the wrist unlocks the box, and the lid is lifted off to the side. The key is provided with a lug on the side which may be used to flip back the lid of the meter. A chisel point is provided on the end of the key for scraping away mud or dirt which may accumulate around the lid. The manufacturers of the Clark meter box have claimed that the box may be unlocked, the meter read and the box locked again in 20 seconds. A series of tests conducted with the long-handle key showed the time consumed to be exactly the same; however, so much less effort was required on the part of the meter reader that the total number of meters read was increased considerably.

The new Clark meter-tester scale beam is designed in accordance with the specifications of the American Water Works Association and the New England Water Works Association. The percentage scale beam is graduated so that the percentage of inaccuracy is based on the amount of water passed through the meter instead of on the registration of the meter. The new scale beam also eliminates all the loose weights which were formerly hung on the end of the scale beam. It is equipped with an electric alarm buzzer, which announces the closing of the test. The sensitivity of the scale has been increased considerably. When the scale is balanced with 100 gal. of water in the tank resting on the scale platform, the addition of ⅛ pt. of water to the tank is sufficient to throw the scale beam out of balance.

The Klinck test and puddle plug, devised by Harry W. Klinck, formerly superintendent of the Logansport, Ind., water works, is used in backfilling trenches after new water mains have been laid.

It is customary, when laying water mains, to test the joints under pressure before placing the dirt back in the trench. Then after the joints are found to be tight the trench is filled in. If the soil is not tamped in layers as the trench is filled, a mound several feet high is usually left over the pipe. Tamping, however, is very expensive and slows up the work considerably.

The test and puddle plug serves two purposes. It is inserted in the end of the pipe and tightened in place. This plugs the pipe and allows the water pressure to be applied for testing the joints. Dirt is then dumped into the trench a few feet behind the end of the pipe to form a dam across the trench. A short piece of 2-in. pipe or hose is coupled into the test and puddle plug, water from the main is allowed to fill the trench behind the earthen dam and the soil is dumped into the trench. No tamping is necessary, as the soil packs as it is dumped in trench. While the trench is being filled the test and puddle plug may be removed to allow the laying of additional main. By this method the trench may be backfilled as the work progresses, thus eliminating the danger caused from open ditches.

The new meter-box ring and lid for tile is for use in cities having old meter boxes consisting of a 15, 18 or 20-in. tile with a flat, loose cover of wood, iron or concrete. This type of box can prove a hazard in many ways, but to replace it with a more modern type involves more expense than many municipalities can bear. The locker ring and lid was designed to meet such conditions. The old cover is removed and the ring fitted in place. Thumbscrews on the under side anchor the ring to the tile. The lid is then placed on the ring and locked in place. This repair job is said to involve only one-fourth the expense of a complete replacement.

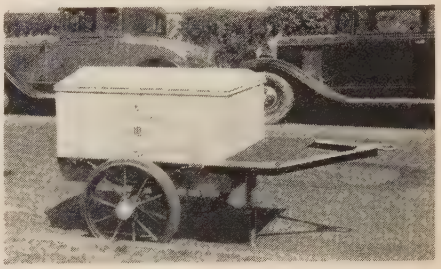
Two New Tool Boxes Increase Littleford Line to Six

Water-works superintendents should should be very much interested in the two new Littleford tool boxes, No. T-1½ and No. T-½.

New Littleford Heavy-Duty Tool Box No. T-1½

No. T-1½ is a heavy-duty box with 1½-ton capacity. Dimensions of the box are: length, 84 in.; width, 40 in., and depth, 29 in. It is mounted on semi-elliptical springs and has rubber-tired wheels equipped with Timken roller bearings. There are convenient compartments for small and large tools.

No. T-½ is a small splicer box meas-



Littleford Utility Tool Box No. T-½

uring 48 in. long, 30 in. wide and 24 in. deep. It has a waterproof top that opens up. Under the top is a convenient shelf and under the shelf a large drawer. The right side of the box opens down and forms a handy shelf when the box is in use. The strong chassis is mounted on semi-elliptical springs and the rubber-tired wheels are equipped with Timken roller bearings.

The addition of these two new all-steel tool boxes increases the complete Littleford line to six: two heavy-duty boxes, two utility boxes and two stationary storage boxes. Write to Littleford Bros., Cincinnati, O., for complete information.

Mathews Modernized Hydrant Announced

Visitors at the St. Louis convention of the American Water Works Association will have the first opportunity to see the important improvements made by R. D. Wood & Co., of Philadelphia, Pa., in the Mathews hydrant.

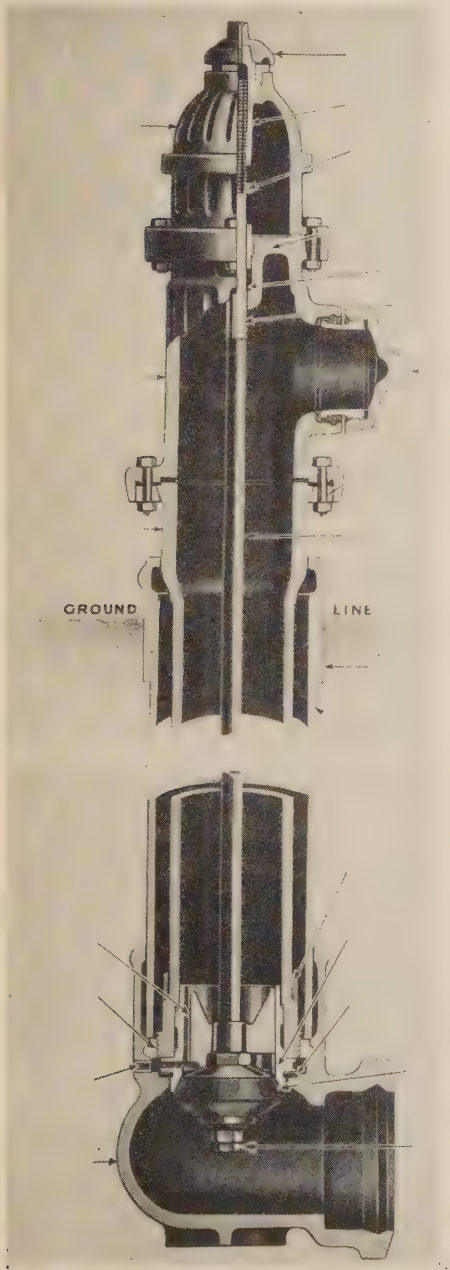
While the basic principles of the hydrant remain unchanged, certain features have been re-designed to meet the modern demand for a hydrant that is stronger, tougher, more resistant to breakage from shock and more easily replaced, if broken by traffic accidents, without digging or breaking the pavement.

The outstanding feature of the Mathews always has been the removability of the barrel, without digging, for repair or replacement. Although more than generally satisfactory in the past, the modernized Mathews improves even this quality. Four sturdy lugs have been cast on the outside of the barrel at the base. A tube wrench slips

down over these lugs, to unscrew the barrel.

At the top of the hydrant a malleable-iron shield-operating nut, resistant to wrench wear, fits down over the bronze operating nut, and is secured by a brass screw in the oil hole. This shield nut prevents rain and sleet from seeping down and freezing around the operating nut.

The wrought-iron operating stem is bronze-bushed at the stuffing box to prevent undue wear on the packing. The stuffing-box plate is cast integral with the nozzle section; thus there is no pressure strain exerted on the head bolts when the hydrant is open, and a separate part is eliminated. As before, there is a bronze stop nut on the stem to prevent the bottom of the stem striking the elbow and buckling, should undue pressure be exerted in opening the hydrant.



Mathews Modernized Hydrant

One of the outstanding new features of the Mathews modernized hydrant is the revolving head, which makes it easy to face the nozzles in any direction, without disturbing the barrel, simply by loosening the bolts in the swivel clamping ring which engages the base flange of the nozzle section.

The overall strength of the new hydrant assures greater resistance to shock. The barrel and protection case sections are cast by the sand-spun method, which produces concentric castings of greater tensile strength, elasticity and toughness.

The cost of replacing broken hydrants has been further reduced by the adoption of a beaded protection case extensions which slips down over the regular protection case. Usually when a hydrant is broken by being struck, it is only the barrel and this extension piece which suffer. The main protection case will rarely be broken, as this beaded extension will receive the major strain of the shock.

The drain valve and the upper section of the main valve are combined in one rugged casting, and the drain valve slides against a bronze cylinder which prevents wear on the liberal size of drain-valve leather. The main valve does not revolve, but moves to and away from its bronze seat with the minimum of friction and wear. Being coneshaped, it opens and closes gradually, thus preventing water hammer and reducing the possibility of gravel or other foreign matter lodging on the seat.

Dependable Remote Indicators for Water Level

Up to this time the extended use of remote indicators and recorders for factors such as water level, temperature, pressure, etc., has been limited because of difficulties encountered in electrical transmission. The old schemes of

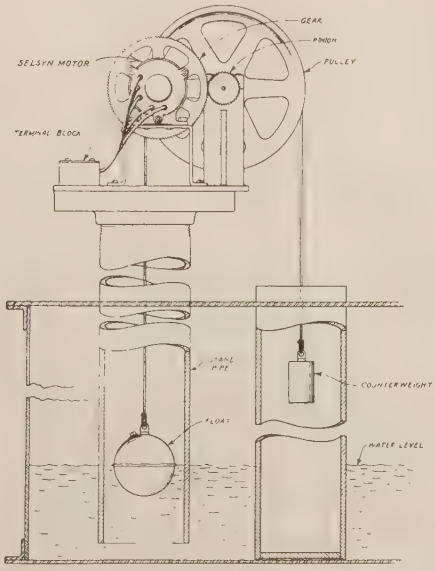


Fig. 1—Transmitting Element Above Maximum Water Level

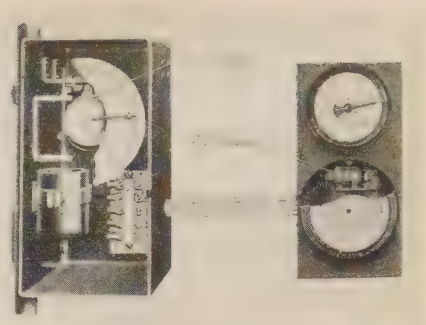


Fig. 2—Selsyn Generator Below Minimum Water Level

transmission were affected by voltage variations and changes in contact resistance, and many of them did not have sufficient power to overcome pen friction on recorders.

These difficulties have been eliminated by the use of Selsyn self-synchronous motor transmission in a new line of Bailey remote indicators and recorders which has recently been placed on the market. The Selsyn motor method of transmission employs a Selsyn generator on the sending end and a Selsyn motor on the receiving end. Three wires are used to connect the stator windings of the generator with those of the motor, while the rotor circuits are connected to a 110-volt supply of alternating current. If power from the same primary source is available at both ends of the system the three wires connecting the stator circuits are all that is necessary for transmission of readings from the generator on the sending element to the motor on the receiving element. The size of wire necessary for connecting the elements depends upon the distance which separates them. A resistance of 35 ohms per connecting wire is allowable.

For transmission of water-level readings the Selsyn generator is turned mechanically by means of a float. On installations where it is desirable to mount the transmitting element above the maximum water level a copper float and chain as illustrated by Fig. 1 are used; and in cases where the Selsyn generator must be located below the minimum water level, a steel float on the open end of a mercury U-tube (Fig. 2) turns the Selsyn generator. When the generator is turned in either direction unequal currents flow in the three lines which connect the stator circuits of the generator and motor. Because of this unequal current flow the Selsyn motor turns through the same angular distance and at the same rate of speed in either direction as does the Selsyn motor. When motion ceases the current flow in the connecting lines becomes equal and is reduced to a negligible amount.

A great variety of receiving instruments is available for indicating and recording the readings transmitted by this system. Round-faced indicators in 27, 17 and 12-in. sizes; one or two-pen

recorders and combination indicating and recording instruments are standard equipment manufactured by the Bailey Meter Co., of Cleveland, O. If desired, several of these receiving instruments can be connected to one transmitting element.

The use of Selsyn transmission is not limited to water level alone but is being used to transmit readings of pressure, temperature, rate of flow, draft and other factors.

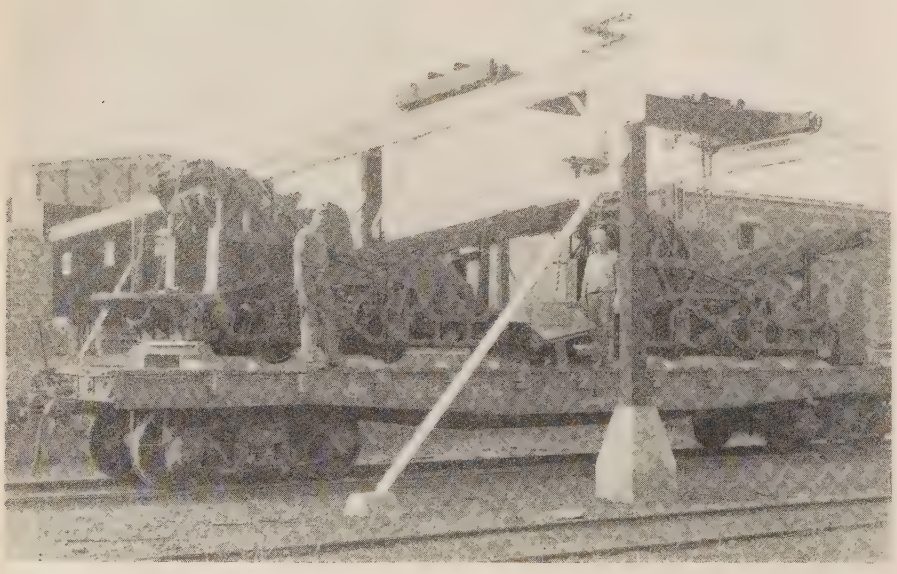
Improvements in Conway Shovels

The accompanying illustration shows two Conway shovels loaded for shipment to the Wachusett tunnel for the water supply of the city of Boston. Six new type 50 Conways were used on this project.

One change in design, noted on the new Conway, is the adoption of an open frame, affording far greater accessibility. The new wheel spread is 54 in.; this additional spread will allow changing the gauge of the machine without having the propeller parts running in between the wheels. The gauge of the new machine can be changed to any other gauge, using the same propeller shaft. On the old type 50 it was necessary to change the propeller unit for every gauge.

The new type 50 has a cast-steel bumper or turntable, whereas the old model had plates. On the mast frame, the I-beam section has been eliminated. The kingbolt is accessible from the outside, whereas on the old shovel it could be reached only from the inside. The new design allows the conveyor I-beam to be bolted right on the bumper and it is not necessary to use the spreader, as on the old type 50. The new Conway has a cast-steel bridge, making the roller unit shorter. The new design also provides for wearing shoes on the boom.

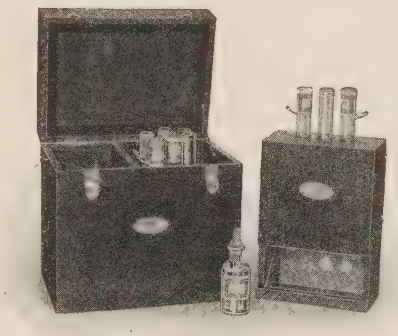
Conway shovels have been used on the Wanaque aqueduct, the Hetch-Hetchy water supply for the city of San Francisco, the Springfield, Mass., Cobble Mountain project and many other water-supply tunnels. Conway shovels are manufactured by the St. Louis Power Shovel Co., St. Louis, Mo.



Two New Conway Shovels Loaded for Shipment to the Wachusett Tunnel of the Boston Water Supply

A New Chlorine Colorimeter

A new piece of equipment, known as the LaMotte chlorine colorimeter, for determining free or residual chlorine in drinking water, has recently been developed by the LaMotte Chemical Products Co., Baltimore, Md. The set consists of eight permanent chlorine color standards in LaMotte sealed Nessler tubes with polished tops and bottoms, representing 0.02, 0.04, 0.06, 0.08, 0.10, 0.15, 0.20 and 0.30 p.p.m. of chlorine respectively; three open Nessler tubes for the test sample; a 50-cc. bottle of ortho-tolidine reagent with 0.5-cc. pipette and nipple, and a LaMott colorimeter for Nessler tube comparison. All this equipment is compactly arranged in a polished wooden case with a sturdy handle for carrying.



La Motte Chlorine Colorimeter

Previously great difficulty has been experienced with standards kept in open Nessler tubes, due to contamination from cork and rubber stoppers, and both contamination and loss of material if the solutions are kept in bottles and poured into the tubes when determinations are made. To eliminate these difficulties, all standards, including those for color, nitrogen, chlorine, iron, nitrate, etc., are put up in closed Nessler tubes with polished tops and bottoms. The standard tubes are filled through side arms which are then sealed off, preserving the standards from contamination of any kind. The special colorimeter must be used in making determinations with these sealed standards.

In making the determination, one of the open Nessler tubes is filled to the mark (50 cc.) with the water to be tested, 0.5 cc. of the ortho-tolidine reagent added by means of the pipette, and the tube shaken to insure thorough mixing and placed in the middle hole of the colorimeter.

Two consecutive color standards—for example, those representing 0.04 and 0.06 p.p.m.—are then placed in the remaining two holes on either side of the test sample. The tops of the tubes are held toward a window or other source of daylight, and the standards changed if necessary, until the color of the reflection of the test sample in the mirror either matches that of the reflection of one of the standards or lies between the two. If an exact match is obtained the chlorine concentration in parts per million is read off directly from the standard with which the match is obtained. If the color lies between those of the standards on either side, the reading is taken as the average of the two. Thus if it lies between 0.04 and 0.06, it is taken as 0.05 p.p.m.

This set is also supplied with permanent standards and reagents for determining nitrogen, nitrates, nitrites, total iron, manganese, etc.

The new principle of making determinations by matching the reflection in the mirror, instead of by looking down through the tubes, makes the readings much more simple and accurate.

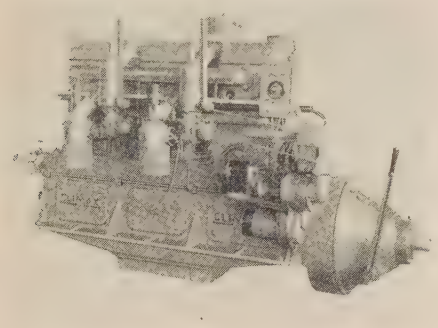
Edson Portable Power Pump Unit

The Edson Mfg. Corp., South Boston, Mass., will exhibit at the St. Louis convention of the American Water Works Association, a recently-developed diaphragm portable power pump—the Edson style OM-T trailer pump unit. This unit embodies the new Edson type M diaphragm pump, which is usable either for open discharge or in connection with a discharge hose as a force pump. This pump will be operated by the Edson air-cooled gasoline engine and mounted on a two-Ford-wheel trailer. This outfit is nicely balanced and is easily managed by one man.

Oil-Burning Engines Announced by Climax

The application of equipment for the burning of distillate on their new Blue Streak engines is announced by the Climax Engineering Co., of Clinton, Ia. These models are produced in five sizes, varying from 70 to 200 hp., and are in the general industrial field.

The outstanding feature of oil burning as applied to these new engines is



New Oil-Burning Climax Engine

the high power and economy being obtained on cheaper fuel, giving about the same performance as gasoline on the average engine of the same displacement. With this increased power, economy in the cost of fuel is marked, the cost running about half that of gasoline. All cylinders on these engines are made of chrome-nickel iron. The bore and stroke are 5½x6½, 5¾x6½, and 6x7 in. in the 4-cyl. models and 6x7 in. in the 6 and 8-cyl. models.

The heads of all of these engines are cast in pairs and are detachable. They are made of chrome-nickel iron with a high Brinell to insure long life.

Crankshafts are drop-forged and heat-treated, and alloy steel is used in the larger sizes. The main bearings are babbitted and bronze-backed and are of ample size and number to insure long life and ability to stand heavy duty. The valves are in the head of the motor and fully enclosed. The intake is of nickel steel and the exhaust is made of silichrome.

Lubrication is highly efficient with a pressure of about 20 lb. to all bearings and overhead-valve rockershaft bearings. The pump is of the eccentric-vane type. A centrifugal pump with shrouded impeller furnishes the efficient water circulation. In conjunction with the special Zenith carburetors used on these engines the intake manifold is jacketed with exhaust heat running warmer than when gasoline is used. A special device also is added, consisting of a heat control of the primary air and water injection. The heat control mechanism consists of a sylphon similar to that used in the spark control mechanism. This is actuated by the change of pressure in the intake manifold, which is transmitted to the sylphon by copper tubing.

A flat valve at one end of the sylphon controls the amount of heated air admitted to the carburetor. As the throttle is opened, the manifold pressure approaches atmospheric and the sylphon expands. The flat valve moves to cut off the hot air from the exhaust jacket and starts to take unheated air until none is admitted when the throttle is wide open.

In order to permit higher power output and higher compression heads, water is injected into the intake manifold for throttle positions greater than three-quarter openings. This is controlled automatically. This water is pumped by an A-C fuel pump, handling water instead of fuel at pressures of from 3 to 4 lb.

New Water-Level Recorder

A small, compact water-level recorder using a circular disk chart has recently been put on the market. It is designated as the Stevens type N water-level recorder, another of the complete line of water-level recording and indicating instruments of Stevens design.

This instrument is completely enclosed in an aluminum case with hinged door. A counterpoised float resting on the water surface moves the pen or pencil laterally a total distance of 4 in. for English units or 10 cm. for metric. The total range of water level is thus reduced to convenient scales of record. The instrument will accommodate a total range of 4 ft. or 1 m. of water-level fluctuations. Height scales may be 5:12, 1:6 or 1:12 in English units or 1:2, 1:5 or 1:10 in metric units.

Instruments may be equipped with 12-hour, daily or weekly charts and for either ink or pencil records. For pencil records a coated paper is used so that the slightest pressure of the pencil makes a distinct line.

Complete information may be had from the manufacturers, Leupold, Volpel & Co., Portland, Ore.

Stevens Type N Water-Level Recorder

New Offset Vertical-Boom Barber-Greene Ditcher

A new product of the Barber-Greene Co., Aurora, Ill., is a light ditcher with an offset vertical boom. The offset boom is not offset in any fixed position but may be set at any desired position between the crawlers on which the machine is mounted, and locked there.

This new product is patterned gener-

Barber-Greene Light Ditcher

ally after the well-known standard vertical-boom ditcher, and there are several noteworthy features incorporated in its design.

The vertical boom—a patented Barber-Greene feature—has become familiar to ditching contractors on the larger B-G model 44-C ditcher.

Another feature of the new utility ditcher is the automatic overload safety sprocket. This affords protection for the machine against overloads, and for pipes and other underground installations against breakage which would prove expensive to the contractor. When an obstruction is encountered, the sprocket slips, stopping the bucket line, catches every half revolution, then slips again. This action will continue without harm to the machine until the obstruction has been removed, or the buckets have milled through it.

The boom is raised and lowered by power, and an automatic throw-out makes it impossible to raise the boom too high.

Whe whole machine is mounted on sturdy crawlers of standard Barber-Greene design by means of a fixed and an oscillating axle. The oscillating axle provides three-point suspension for the machine, which enables it to ride over rough ground and stay on an even keel.

The machine is powered with a Buda 38-hp. gasoline engine and is driven through two especially designed transmissions. It has four road speeds—three forward and one reverse, with a high forward speed of 2⅛ m.p.h.—and a great number of digging speeds, ranging from 12 to 148 in. per minute. There are cutting speeds to suit any soil condition.

The utility ditcher cuts a trench from 9 to 18 in. wide and from 4 to 5 ft. 6 in. deep. It is light, compact and sturdy.

Pipe-Handling and Backfilling Unit

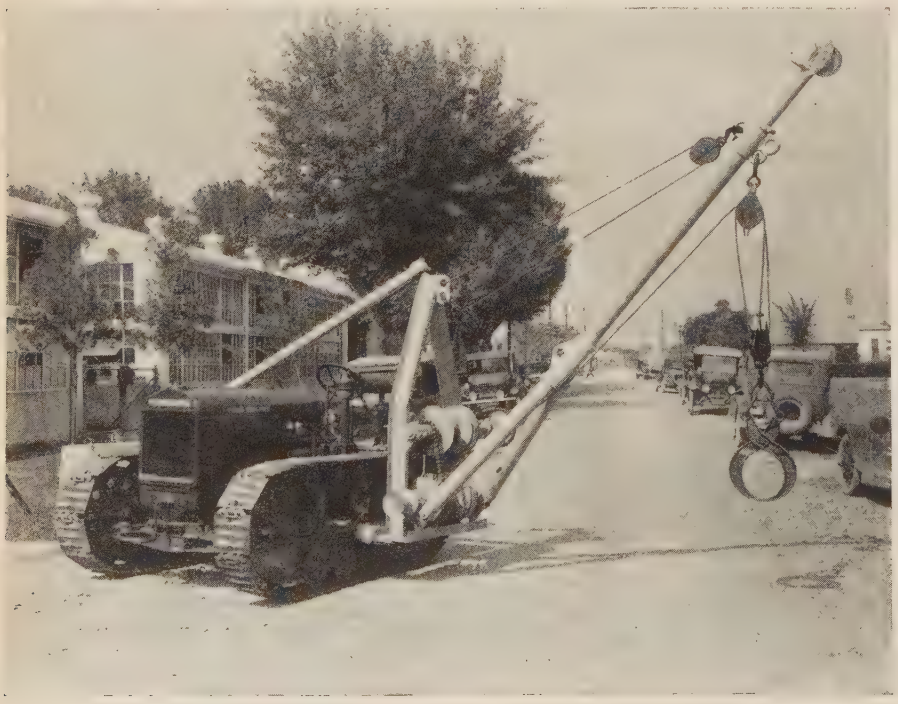
The W-K-M boom and side winch is now being manufactured for mounting on the model DH Trackson McCormick-Deering tractor. This equipment, which is made by the W-K-M Co., Inc., Houston, Tex., greatly increases the versatility and usefulness of the Trackson unit. With the W-K-M boom it is adaptable to backfilling, by the use of a throw-back bucket or Mormon board, pipe handling and laying and other similar operations.

This combination of equipment is stated to lift and carry loads of 4,500 lb. and will raise much heavier loads when a stiffleg is used.

The boom may be mounted on the tractor quickly and easily in the field, since the installation requires no drilling or cutting. An outstanding advantage is the fact that the boom when installed does not interfere with the use of the tractor for drawbar operations.

The W-K-M equipment is made of best quality steel castings throughout. The normal length of the boom is 13½ ft.; extended, its maximum length is 19 ft. The side winch has two drums, each with a capacity of 495 ft. of ½-in. cable. The clutches are of the internal expanding, two-shoe friction type, 13¾ in. in diameter and each 35 in. long. All shocks and strains to the boom and side winch are absorbed by A-frames provided at each side of the tractor, and the equipment is provided with ball-and-socket joints thoughout to overcome strain through track oscillation.

Mormon boards, special sheaves, stifflegs, pipe hooks for various sizes of pipe and other extra equipment for this unit may also be obtained. Either the Trackson Co., Milwaukee, Wis., or the W-K-M Co., Inc., Houston, Tex., will furnished complete information on request.



W-K-M Boom and Side Winch Mounted on Model DH Trackson McCormick-Deering

FWD Auto Eductor

One of a pair of FWD sewer cleaners recently put into service by the city of Milwaukee, Wis., is shown in the accompanying photograph.

FWD Auto Eductor in Service in Milwaukee, Wis.

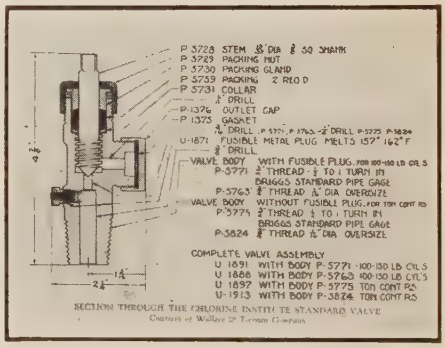
The unit consists of a watertight body holding 1,200 gal. or 6.2 cu. yd., mounted on a six-wheel truck with four-wheel drive on the front and first rear axles. The truck is equipped with ten tires to carry the enormous weight of the machine. When the sewer cleaner is to be operated, the large tank on the truck is filled two-thirds full of water. A pump operated by a separate motor is connected with this body. On reaching a catch-basin, two telescopic pipes are lowered into the filth. The pump draws water from the body and forces it down into the catch-basin in one of the two pipes. At the end of this pipe is an elbow which is fitted on the end with a nozzle which reduces the downcoming 3-in. stream down to 1⅛ in. in size. The reduction in size of the stream increases its speed and velocity and also creates a suction. Around the nozzle which points upward in the second telescopic pipe is a collar or opening which permits refuse to be sucked in. The suction created by the swiftly moving stream draws in the catch-basin refuse and it is immediately hit by the stream of water and forced upward in the pipe to the body or large tank on the truck.

This dirty fluid is carried to the rear of the body and released there. The dirt in the water settles to the bottom of the tank and the water works its way through baffle plates toward the front end of the body. Pumping is kept up from one catch-basin to the next until all the water in the tank has been displaced by muck and the tank is full of refuse. The unit is then driven to a dump and unloaded. Because of the bad roads ordinarily found in the dumping grounds and the unusually heavy load to be carried, the four-wheel-drive feature is very desirable.

This unit is manufactured by the Four Wheel Drive Auto Co., Clintonville, Wis.

The Chlorine Institute Valve

A development of the past year worthy of mention is the increased use of the new Chlorine Institute standard

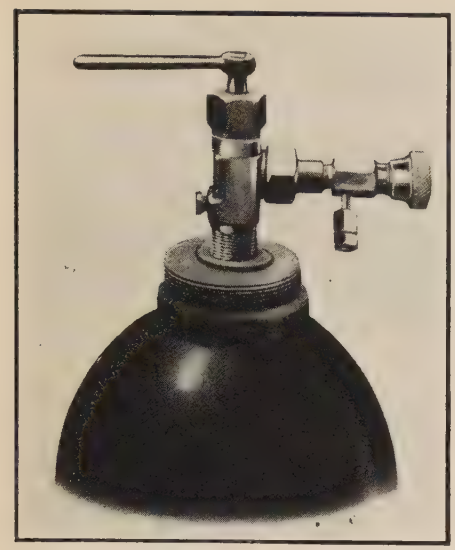


Section Through Chlorine Institute Standard Valve

tank valve for chlorine cylinders and drums, produced through cooperation between equipment manufacturers and health and water-works officials.

Although water-works officials had for years, on frequent occasions, experienced delays and inconveniences due to receipt of a shipment of chlorine-gas cylinders requiring yoke connections for auxiliary valves when fittings on hand were for the union type of attachment, and vice versa, it required an emergency situation developed in the course of relief work following the Florida hurricane of 1926 to bring the seriousness of the then existing practice to a head.

The incident in point occurred at Hollywood, Fla., in September, 1926,

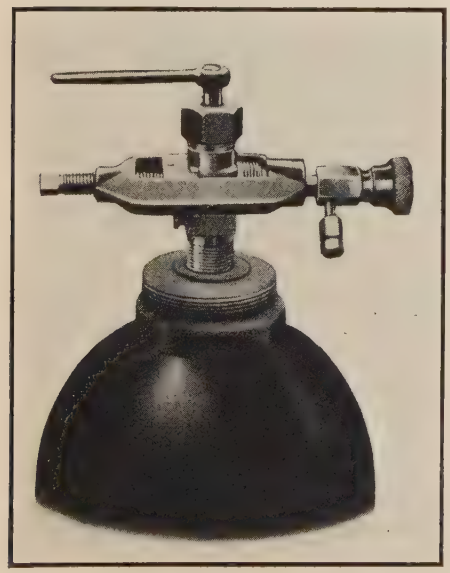


Chlorine Institute Standard Valve with W&T Union-Type Auxiliary Valve

when a shipment of several cylinders of chlorine gas delivered for emergency chlorination of water supplies could not be used because the cylinders required yoke-type fittings while only the union-type connections were on hand.

At a special meeting of the Public Health Engineering section of the American Public Health Association on Oct. 13, 1926, at Buffalo, N. Y., experiences in emergency chlorination of public water supplies following the Florida hurricane were the subject of a very interesting discussion. Before the close of the meeting the following motion was made, duly seconded and carried unanimously: "Moved that the secretary communicate with the Chlorine Institute and also the American Water Works Association with reference to the standardization of tank valves on chlorine cylinders."

On receipt of a communication from



Chlorine Institute Standard Valve with W&T Yoke-Type Auxiliary Valve and Yoke

Arthur E. Gorman, secretary of the Public Health Engineering section, referring to this action of the section and requesting its serious consideration by the Chlorine Institute, the directors of this organization at a meeting on Dec. 16, 1926, forwarded the communication to a special technical committee for investigation. This committee, after a very careful survey of conditions and a study of all types of valves, designed an entirely new valve, adaptable to both union and yoke-type connections, which was accepted and is now being manufactured. It is known as the Chlorine Institute valve.

Investigations of this committee showed that but a relatively small percentage of the chlorine valves owned by manufacturers in the chlorine industry were used in the sanitary field; also that the investment in these valves was a substantial one, making their discard for new valves an expensive matter. However, in view of the health aspects of the situation, the manufacturers decided on a policy of purchasing Chlorine Institute tank valves for the replacement of all discarded valves in use. The replacement by new valves was then confined entirely to containers used in the sanitary field.

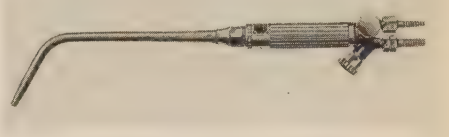
It was estimated that this procedure would over a period of a few years permit the replacement of all valves used in the sanitary departments of their business with the new Chlorine Institute tank valve. It is estimated that to date there are approximately 25,000 of the new valves in use.

They are being manufactured exclusively by the Wallace & Tiernan Co. and users report very satisfactory results with them. The new valve incorporates the best features of all valves in service. Among the features of the valve are a one-piece genuine monel metal stem; a brass forged body with 3/16-in. seat opening for the cylinder valve and ¼-in. seat opening for the ton-drum valve; an extra long and over-size shank thread which allows for wear of the thread in the cylinders and gives increased length of life of the body; brass packing nut, gland and ring, so arranged as to permit packing the valve while in service; the use of soft packing, and the use of a removable bronze fusible-metal container plug. The fusible metal repsents the result of extensive research work carried on by the members of the Chlorine Institute. The outlet connection has the ¾-in. external straight pipe thread which has been used in the industry for years to accommodate a union connection and is also equipped with a recessed gasket surface to accommodate the use of an adapter and yoke. The packing nut takes the same wrench as the outlet cap.

Another New Oxweld Welding Blowpipe

The Oxweld Acetylene Co., New York, N. Y., has recently announced another new blowpipe. The type W-17, as it is called, employs the same well known low-pressure injector principles used in other Oxweld blowpipes. It is somewhat similar in design to the type W-15 aircraft-welding blowpipe which has met with such great favor since its introduction about a year ago. The type W-17, however, is a full-sized blowpipe, large enough for any welding job and so carefully designed and constructed that it may be used for the finest of welding craftsmanship.

New principles of design have been incorporated in this blowpipe. The tip and welding head are of one-piece construction, being combined in a long and slender stem of the gooseneck type. Careful study has been devoted to the design of the injector and mixing chamber for each of the ten welding heads. The injector is at the base or handle end of the stem. Each welding head has its own nut for attaching it to the handle of the blowpipe. The



Oxweld Type W-17 Blowpipe

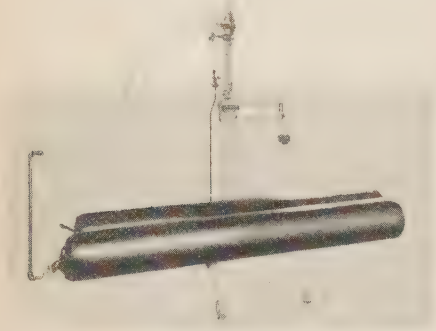
nut has been constructed so that it extends beyond the injector when the welding head is detached from the blowpipe and serves to protect the injector from damage due to careless handling. A fine-pitch thread makes it possible to tighten or loosen the nut easily without the use of a wrench. The handle of this new blowpipe is made of a special brass tubing having longitudinal ribs. This offers a sure grip to the operator and also reinforces the handle. The valve wheels are of a new design and are placed so as to be readily accessible, yet out of the way during the welding operations.

The type W-17 blowpipe is compact and light. With the No. 4 welding head it weighs but 24 oz. The long, thin shape of the welding heads make it possible for this blowpipe to be used in places inaccessible to almost any other type of equipment.

The inner cone of the flame of the type W-17 blowpipe is somewhat different from that obtained with any other blowpipe. It is shorter and thicker and has a tendency to assume the shape of a ball at the end. This speeds up the rate of welding because a large portion of the high-temperature flame (or inner cone) surface is brought closer to the metal.

A New Ammonia-Feeding Apparatus

The Paradon Mfg. Co., Arlington, N. J., has developed an apparatus for the application of anhydrous ammonia known as the Paradon ammoniator. The ammoniator consists essentially of a Paradon dry-feed chlorinator constructed of materials that will withstand and handle ammonia.



Paradon Ammoniator

The anhydrous ammonia enters the apparatus as a gas under full tank pressure. The ammonia pressure gauge indicates the tank pressure of the ammonia upon entering the apparatus. The pressure of the ammonia is materially reduced by an inlet valve actuated by a diaphragm. The ammonia passes along the diaphragm and through the orifice. The flow of the ammonia is regulated by varying the drop in pressure through this orifice. A manometer indicates the flow of ammonia through the orifice. The flow through the orifice is regulated by regulating the difference in pressure between the front and rear of the diaphragm. After passing through the orifice, the ammonia flows through a meter pressure and shut-off valve. The function of this valve is to maintain the ammonia at a back pressure equal to the back pressure under which the orifice is calibrated. The shut-off valve enables the apparatus to be shut down when not in use and kept filled with ammonia under pressure, thus preventing the entrance of moisture or dirt. From the meter pressure-shut-off valve, the ammonia goes directly to the point of application.

If desirable, the ammoniator can be provided with an injector, and the ammonia gas first mixed with an auxiliary water supply in the injector and the resultant ammonia solution applied at the desired point of application.

The ammoniator can be mounted on either a metal pedestal or it can be combined with a platform scale. The ammoniator is ordinarily finished in light green Duco enamel.

The ammoniator enables the ammonia to be applied accurately and thus makes it possible to maintain constant the ratio between chlorine and ammonia found most suitable for the plant. The ammoniator also prevents any possibility of freezing due to too rapid expansion of the ammonia. It, of course, prevents the leakage of ammonia, which is an objectionable gas unless properly controlled.

The ammoniator can be used not only for the application of anhydrous ammonia in the water purification, swimming and sewage fields, but also for controlling anhydrous ammonia for practically any purpose.

Two New Unit Trenchoes Announced

New products of importance to the water-works and sewerage field are the new Unit trenchoes, models 310 and 512. These models are innovations in that the structural member of the boom is circular in cross-section. These trenchoes are manufactured by the Universal Power Shovel Co., Milwaukee, Wis., a division of the Unit Corporation of America.

The cylindrical boom has proved its great strength after long, severe tests. Recently a machine, after completing a water-main trench in Detroit, moved into a basement to assist in digging the foundation. The excavation yardage compared very favorably with shovel operation because of the speed of the dipper, which can easily move through four dips per minute.

Another important feature in this small, fast trenchoe is the new disc-type clutch. The clutch is so constructed that it can be adjusted at a single point without the assistance of a wrench and the adjustment is a matter of seconds only. The clutch facings are guaranteed for a year. This unit clutch makes operation easy—so light, in fact, that it is stated the operations can be controlled by the pull of a finger.

The gears are all of drop-forged, double-heat-treated alloy steel. Bores are ground true to center after heat treatment.

Unit excavators are presented as machines which can render important service in moving material at low yardage cost. The trenchoe is easily and quickly converted to shovel, clamshell, dragline, crane and backfiller; and these changeovers may be made readily in the field.

Automatic-Priming Pump by Domestic

A recent development of the Domestic Engine & Pump Co., Shippensburg, Pa., is their No. 3, type 52, 3-in. automatic-priming centrifugal pump. These units are automatic priming and will

Domestic 3-In. Automatic-Priming, Trash-Handling Pump

prime themselves from vertical lifts up to and including 27 ft. The priming device consists of a highly-efficient vertical, piston-type vacuum pump, a vacuum-control regulator and an air-tight check valve in the discharge line of the centrifugal pump.

These units are designed to handle not only clear water, but also solids approximately one-half the diameter of the intake opening of the pump. They will handle such debris as sticks, stones, muck, etc., and have worked out very satisfactorily with contractors and sewer departments in different cities.

The 4-cylinder engine has a speed range of from 900 to 1,400 r.p.m. and develops 10¼ hp. at 1,400 r.p.m. Standard mounting consists of a two-wheel trailer with rubber cushion tires. Plain steel-tired wheels can be furnished if desired. A four-wheel truck, as shown in the illustration, is furnished on special order. Capacities for various heads may be secured upon application to the manufacturer.

Unit Model 310 Three-Quarter-Revolving Trenchoe

Paige & Jones Apparatus

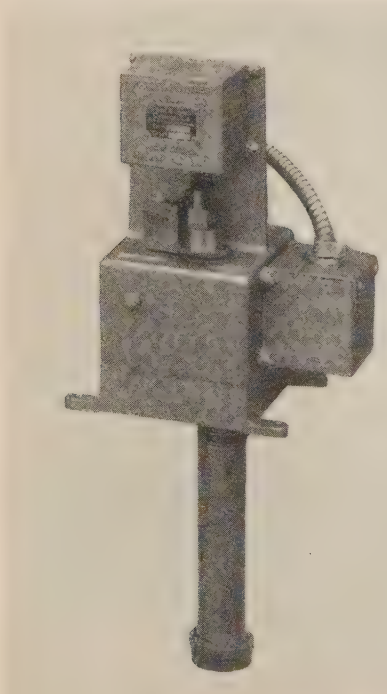
Two new devices, a hydro-acid pump and an electromagnetic proportioner, have been brought out during the past year by the Paige & Jones Chemical Co., Hammond, Ind.

The hydro-acid pump is the result of demands for an adjustable-stroke, low-capacity, cheaply-maintained pump to handle ferric alumina, ferric chloride, aluminum sulphate and any other acids in concentrations not injurious to rubber.

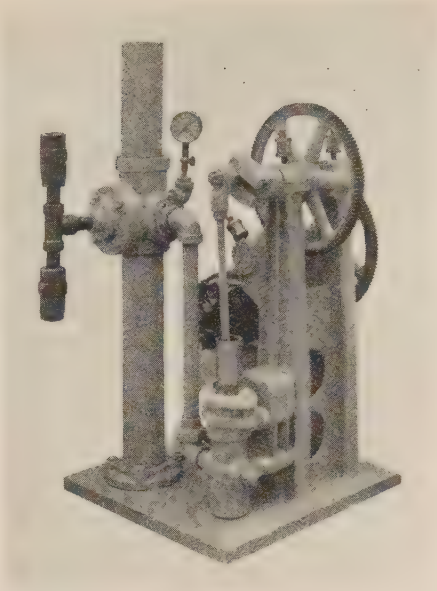
Referring to the illustration, the acid part of the pump consists of the hard-rubber check valves and fittings shown at the extreme left which pass through the side of the cast-iron and steel cylinder connecting with a gum rubber sack which hangs within this cylinder. There is nothing more than this to the acid portion of the pump and it is quickly and easily removed for inspection or repairs if needed.

The pumping impulse is supplied by water or other suitable hydraulic fluid on the outer side of the rubber sack in the steel cylinder, pressure and vacuum alternately being applied to the solution, thus causing the rubber sack to fill and empty itself at pressures up to 125 lb. per sq. in. The alternating impulses to the hydraulic fluid are supplied by an ordinary piston pump with an adjustable stroke geared to a General Electric motor.

The upper part of the casing at the left contains mechanism for preventing the collection of air in the hydro side of the system due to leakage at the piston.



Paige & Jones Electromagnetic Proportioner



Paige & Jones Hydro-Acid Pump

The pump is built in standard sizes of 60 g.p.h., 150 g.p.h. and 300 g.p.h., and larger on special orders. The pump is guaranteed self-priming and dripless, there being no stuffing-box in connection with the acid part of the pump.

The electromagnetic proportioner shown in the accompanying photograph is an improvement over the model brought out by Paige & Jones last year in that it contains a magnetic clutch and dashpot.

This device makes possible more accurate proportioning of chemicals to water. It is used in proportioning lime, soda-ash or any other chemical. It operates off a meter with electric contacts and, since the stroke of the solenoid can be lengthed or shortened at will, immediate readjustment of chemicals is possible.

A large number of these devices have recently been installed at water treating plants on railroads, industrial plants and municipal plants where greater accuracy of proportion and instantaneous readjustment are desired features. The device is essentially a robot and performs its duty as all good robots should.

Armco Drainage Developments

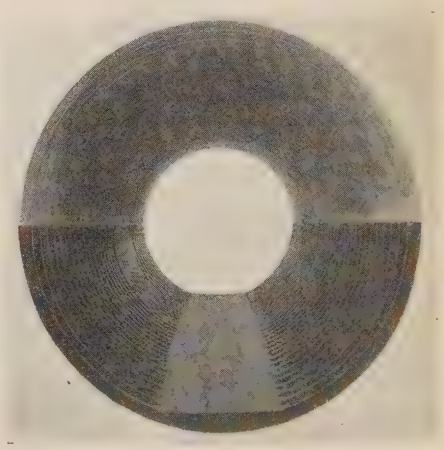
Increased use of Armco corrugated-iron pipe, installed by the Armco jacking method as conduits for water mains, gas lines and sanitary sewers is reported by the Armco Culvert Manufacturers' Association, Middletown, O., by whom this method was developed.

Numerous openings created under busy streets, railroad lines and high embankments have shown this means of conduit installation to be possessed of the following advantages: no interruption to traffic, no marred pavement to replace or settling fill to maintain and usually a much lower cost of installation than that by the tunneling or open-trench method. Where traffic is heavy and covering shallow, laying the main in the sturdy corrugated-iron pipe protects it from vibration. If for any cause a break should occur in a high-pressure line, the escaping stream is confined to the conduit and the pavement or roadbed protected from damage. Where the necessary provisions are made, this method also allows ready access to the main for the purpose of making repairs.

The passing of another year of service has brought additional evidence of the economies of Armco paved-invert pipe, the result of the first successful effort to incorporate the principle of balanced design into drainage structures. In this product, the bottom or invert of the pipe, which the investigation of thousands of culverts of all types has shown to receive the greatest wear, is paved with a special bituminous material which protects the invert from erosive action of abrasive materials that are carried by the water. With the exception of the pavement, Armco paved-invert pipe is the same as the regular Armco corrugated-iron pipe which has completed its twenty-fourth year of continuous service.

Because of the lightweight continuous construction of this type of pipe and its service-proved strength and durability, municipalities are finding in it a quickly installed and economical storm sewer. Special economies are obtained by its use for outfalls and other purposes where unstable soil conditions would necessitate special foundation work for the heavier, rigid types of construction.

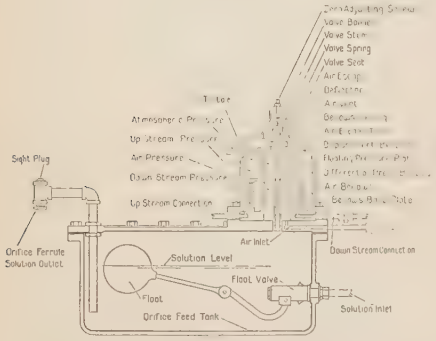
Full information on the Armco jacking method of installing conduits and the uses and economies of Armco paved-invert pipe may be secured upon request from the Armco Culvert Manufacturers' Association, Middletown, O.



Interior of Armco Paved-Invert Culvert

Cochrane Products for the Treatment of Water

Accurate proportioning of one fluid to another is required in various processes, as, for example, the softening of water. Devices are in use in which the primary stream and the secondary



Cross-Section of Cochrane Air-Balanced Proportioner

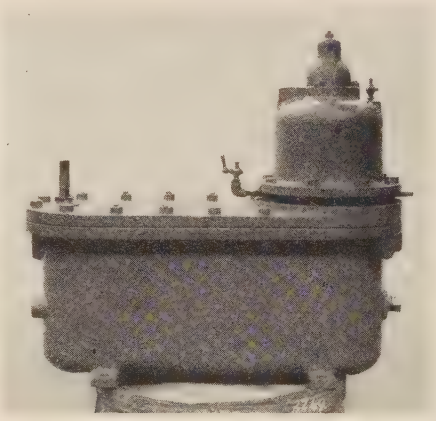
stream are each measured by means of the pressure differential due to flow of the respective streams through an orifice, the two pressure differentials acting upon a balance by which the flow of the secondary fluid is controlled automatically. In some instances, however, the fluid to be controlled may be corrosive, or otherwise of such a nature that it is not desirable to have it come into direct contact with the diaphragms or pistons of the balancing mechanism.

The air-balanced proportioner shown herewith has been developed by the Cochrane Corp., Philadelphia, Pa., to overcome this difficulty. Referring to the sectional view, it will be seen that the corrosive solution is held at a constant level in a feed tank by means of a float-regulated valve which controls inflow from a source of higher pressure, while the outflow of the corrosive solution is through an orifice. The pressure acting upon the outflow orifice is determined by the air pressure above the liquid level in the solution tank, this pressure being regulated automatically as described below.

Mounted upon the solution tank is a balancing device consisting of three corrugated bellows, all attached to a single movable diaphragm which carries on an axially-placed tube a valve member co-acting with a stationary valve member at the top. The surface of the diaphragm contained within the inner pair of bellows is acted upon beneath by the air pressure within the feed tank, while the upper surface is open to the atmosphere. The annular portion of the diaphragm outside of the inner bellows and within the outer bellows is acted upon on its upper surface by the pressure from the upstream side of an orifice in the primary flow pipe and upon its under side by the pressure from the downstream side of the same orifice.

The differential due to the flow of the primary liquid is thus balanced against the pressure within the orifice feed tank. Should the latter be greater in proportion than the differential due to the primary flow, the valve member will rise and allow some of the air in the orifice solution tank to escape. On the other hand, should the differential pressure be the greater, the orifice member will fall so that no air can escape; but inasmuch as air is constantly flowing into the solution chamber from a supply source, the air pressure will build up until the valve will again be lifted. In other words, in operation the valve is always leaking more or less and the pressure within the orifice feed tank is always proportional to the differential due to flow of the primary liquid. The rate of inflow of air into the orifice feed tank is through a small orifice in the supply pipe. If the pressure of the source from which this air is taken is roughly more than twice the highest pressure carried in the orifice feed tank, the rate of inflow will be constant.

From the sectional drawing it may be seen that the entering air first flows into the space within the lower inner



Cochrane Proportioner for Corrosive Solutions

bellows and then downward through the clearance around the tube attached to the diaphragm and serving both to guide the diaphragm and to carry the valve member. The outflow of air to the valve takes place up through this tube. There is thus no opportunity for acid vapors to penetrate into the bellows chamber and attack the bellows; also, most of the air flowing out through the valve will be fresh incoming air and not acid-laden.

When the apparatus is put into operation, a spring bearing upon the top of the movable tube is so adjusted that pressure will be held in the orifice feed tank just sufficient to raise the acid solution to the level of the outflow orifice when there is no differential pressure from the primary flow pipe. The flow through the primary flow pipe causes a differential loading to be applied to the bellows which increases as the square of the rate of flow. An equivalent opposing air pressure will at the same time be built up in the feed tank and the flow of acid out through the orifice will vary as the square root of this air pressure, and will, therefore, be directly proportional to the flow of the primary fluid. The outflow through the orifice takes places into an open funnel, so that it can readily be inspected.

The tank from which the acid solution is received may be located below the air-balanced proportioner and the acid lifted up to the latter by admitting pressure from the primary air supply to the solution tank. Similarly, the latter may be fitted with a calibrated measuring tank and with air pressure connections so that acids can be charged into the solution tank without releasing the pressure on the latter. The supply for the proportioner may be also obtained from an elevated tank or by means of a constantly-running centrifugal pump if desired.

To secure good mixing in the solution tank, various agitating means may be used, one frequently used consisting of a perforated air pipe. In other cases mechanical agitators may be employed.

Another Cochrane development is a de-aerator, designed especially for protecting the piping of hot-water heating and service systems from oxygen corrosion. Briefly, the process employed comprises the following steps:

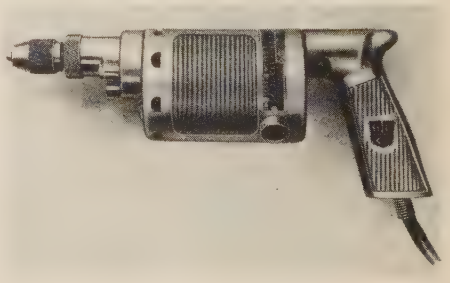
1. The water is heated to the temperature at which water boils under the total pressure of the atmosphere which is actually in contact with the water.

2. The water is distributed over trays and agitated, thus increasing the area of the liberating surface from which gas may escape.

3. The atmosphere in contact with the water is continually removed and replaced by pure steam in order to carry away the liberated gases through a vent.

New General-Purpose Drill by Goodell-Pratt

The Goodell-Pratt Co., Greenfield, Mass., has recently brought out a ¼-in. general-purpose electric drill which has some unusual features. It is powered for a ¼-in. general-purpose drill by a Westinghouse motor. The spindle is full ball-bearing and the gears are made from heat-treated alloy steel. Ample ventilation is provided, the air



Goodell-Pratt ¼-In. General-Purpose Electric Drill

being drawn from the back of the housing up through the pistol-grip handle. This keeps the drill cool and comfortable to use with either one or two hands. Ribbed panels on the handle and housing afford a good grip to the operator and at the same time act as cooling fins. The switch handle is a rubber-covered ball, placed to be easily controlled by a flick of the thumb. The brushes are set at an angle so as not to interfere with close drilling in corners. The drill is rated for ¼-in. work in iron or steel, and the manufacturers state that one man cannot stall it by any legitimate means. It weighs 4¼ lb.

Gear-Operated Bulldozer for Monarch Tractors

A new gear-operated bulldozer has been designed for use with Allis-Chalmers Monarch 50 and 35 tractors by Niess & Co., Inc., of Minneapolis, Minn.

This bulldozer is made in two types, the bulldozer with rigid blade and the backfiller with adjustable blade. The

New Gear-Operated Bulldozer for Monarch Tractors

adjustable blade is set unusually near the front of the tractor and is supported and propelled at both ends, a feature which greatly reduces side draft.

The power-transmission unit, composed of pinion and bevel gear, together with spur pinion and gear segment, is employed in connection with a Twin Disc clutch and brake. Gears are enclosed in an oil-tight housing attached to the transmission case of the tractor, while the clutch and brake are mounted on the outside of the gear case to be readily accessible.

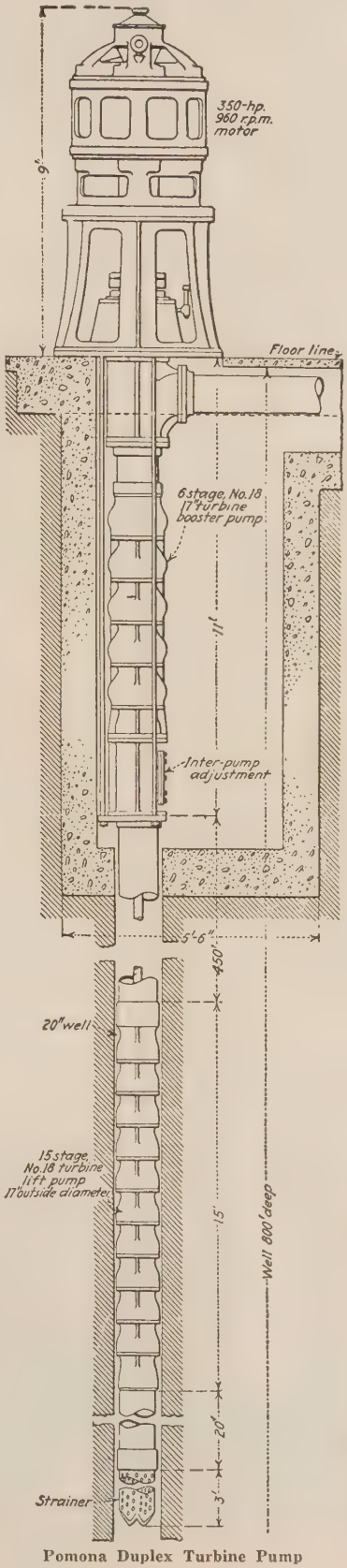
Advantages of the gear-operated bulldozer include fast and positive action of the blade, a wide travel radius of the blade and additional clearance when high obstructions are encountered. The blade is controlled by a single lever and can be locked in the ground or allowed to float.

Anti-friction bearings are used in the transmission unit, and all moving parts are set on lubricated bearings. Electric welding is employed throughout.

Attaching this bulldozer to a Monarch tractor does not interfere with the use of other equipment on the drawbar.

Pomona Duplex Turbine Pump Finds Favor

The modernization of water production methods has developed many new and important pump types. Among these newer pumps one of the most advanced designs is what is known as the duplex turbine type. Hydraulic engineers have shown great interest in this mechanism because of its efficient operation even at depths as great as 1,000 ft. in drilled wells.



Pomona Duplex Turbine Pump

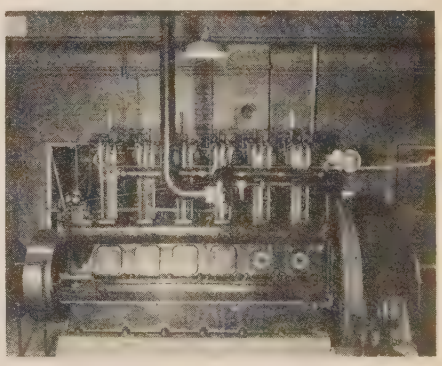
Pumping from the water level in a drilled well to the surface or pumping from the water level of the well to an elevation high above the ground level is effectively accomplished by the duplex turbine pump, according to the manufacturers. In the first case, the upper set of stages is installed midway between the surface and water level of the well. When part of the lift is above ground the upper stage assembly is placed directly under the pump head. The outline drawing shown here is of the latter style.

The independent booster pumps ordinarily used are eliminated. Greater operating economy is claimed to be the result of using but one motor and one starter. Power consumption is reduced from 15 to 25 per cent, according to engineers. Both groups of stages are driven through the same pump shaft by the same motor. Thus speeds are identical and capacities are synchronized.

"The demand for this style of equipment," according to W. H. Day, vice-president and general manager of the Pomona Pump Co., manufacturers of this type of pump, "was foreseen by our engineers several years ago and experimental work was started at that time. This dual pumping principle, combined into one unit, is finding favor in many districts where very deep lifts are encountered and eliminates the necessity of booster mechanism."

Chicago Pneumatic Engines in Water-Works Service

Engines of the Chicago Pneumatic Tool Co. have been installed in a number of water-works plants throughout the country. The type RHG-40 shown in the accompanying illustration drives an Aldrich triplex pump in the Beaver, Pa., plant. The pump has a rated capacity of 2 m.g.d. against a total head of 460 ft. The engine is rated at 198 b.hp. at 260 r.p.m. Natural gas is used for fuel.

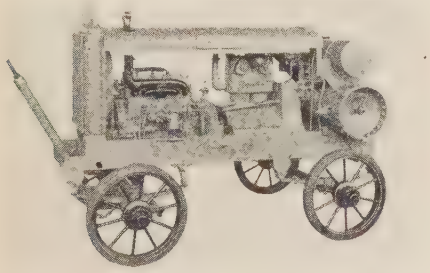


Chicago Pneumatic Engine at the Beaver, Pa., Water Works

Sullivan Adds Small Vibrationless Compressor

The accompanying photograph shows a new addition to the Sullivan line of "vibrationless" portable air compressors.

This is the 66-ft. machine, the smallest size thus far manufactured, which



Sullivan 66-Ft. Portable Compressor with Rubber-Tired Wheels and Spring Mounting for Use on City Streets

compares with the 110-ft. Sullivan compressor in general appearance and construction. This new size finds a place among contractors, public utilities and municipalities who have a variety of jobs to perform from time to time requiring small amounts of compressed air.

The 66-ft. WK-312 compressor has two vertical cylinders, 4¾x4 in., run by a 4-cylinder, 18-hp. gasoline engine, direct-connected, and is good for 100 lb. pressure. It can be furnished with steel wheels, on which it weighs 2,500 lb.; on spring mounting with rubber tires, as shown in the picture; on skids, or on a two-wheel trailer.

In design, construction and operating equipment, this unit is merely a smaller member of the well-known Sullivan portable line, and the same performance as from larger Sullivan compressors is being secured with the "baby" of the family. This new compressor is described in a new 40-page air-compressor bulletin distributed by the Sullivan Machinery Co., Chicago, Ill.

Media for the Coli Test

The presumptive test for B. coli is of vast importance to all who are concerned with the safeguarding of water supplies. The colon bacillus is the indicator of pollution and sounds the warning of danger of epidemic outbursts of intestinal disease. Typhoid, enteritis and dysentery in all their forms are water-borne infections indicated by the presence of B. coli.

A rapid and accurate method for detecting the colon organism is a necessity to any worker in a water-works laboratory. Many cultural methods and tests have been proposed for this specific purpose. Some of these methods have come into quite general use.

Bacto brilliant green bile 2 per cent, developed by the Digestive Ferments Co., Detroit, Mich., at the suggestion of Committee No. 1 on Standard Methods of the American Water Works Association, has met with the approval of many laboratory workers. This dehydrated medium is simple to prepare and yields uniform media with which comparable results are assured. The growth of the gram-negative, non-spore-forming, lactose-fermenting organisms of the colon group in this medium indicates recent pollution. The growth of spores and other organisms capable of fermenting lactosa is inhibited. The confusion which such organisms might cause in the interpretation of results is greatly reduced.

Baco lactose broth is another product manufactured for the laboratory worker seeking evidences of pollution. This product, when made up for use, yields a medium conforming in every way—ingredients, formula, reaction—to the requirements of "Standard Methods of Water Analysis" of the American Public Health Association. Lactose broth prepared according to these standards is the official medium for the detection of B. coli in water. Bacto lactose broth, in its dehydrated form, is a stable and uniform product, easily made up for use; and yields a medium identical in every way with the official medium.

Bacto brilliant green bile 2 per cent and Bacto lactose broth are both extremely useful to the bacteriologist in the water-works laboratory. For the routine examination of waters which are ordinarily quite free from contamination Bacto lactose broth is recommented. In cases where a water supply is liable to pollution or contamination, the presence of non-intestinal organisms frequently causes confusion and delays the interpretation of results. In such instances it is sometimes preferable to use a partially inhibitory medium such as Bacto brilliant green bile 2 per cent.

Further information about these and other media useful to the water-works bacteriologist will be furnished by the Digestive Ferments Co., Detroit, Mich.

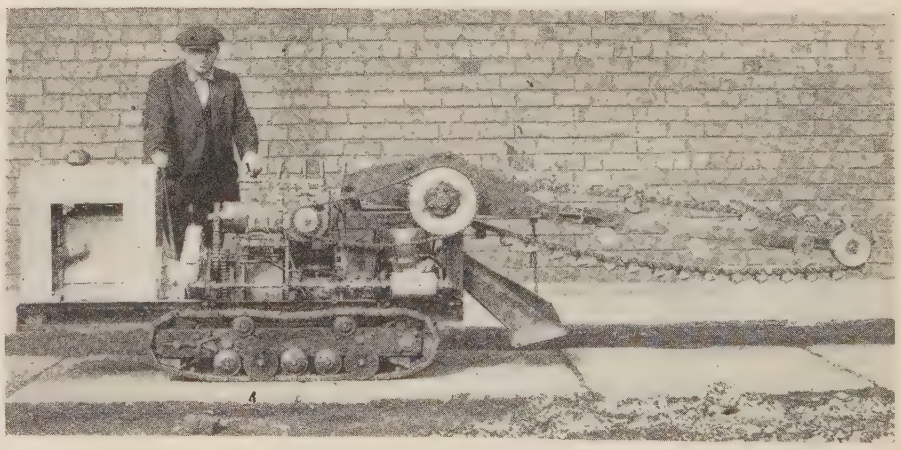
New Motor Housing for Turbine Centrifugal Pump

Since the introduction of turbine centrifugal pumps requiring vertical motors, no concerted attempt has apparently been made to design the motor housing as an integral part of the pump, according to H. G. Steele, president of the U. S. Electrical Mfg. Co., Los Angeles, Calif. Heretofore, the base of the pump, resting upon the concrete at the surface of the ground, was designed by the manufacturer to meet his needs and when the motor was set upon the pump, according to Mr. Steele, sometimes an awkward assembly that was both ugly and not in keeping with good engineering practice resulted.

U. S. Electrical engineers some time ago began the study of electric-motor construction as applied specifically to turbine centrifugal pumps, and finally developed a new motor housing which will be known as the U. S. Turbo pump motor. None of the operating units is exposed and the motor is said to be weatherproof. It is designed with the operating parts fully protected and is symmetrical. When set upon the pump base it is said to offer a very pleasing appearance.

C. H. & E. Trench Digger Announced

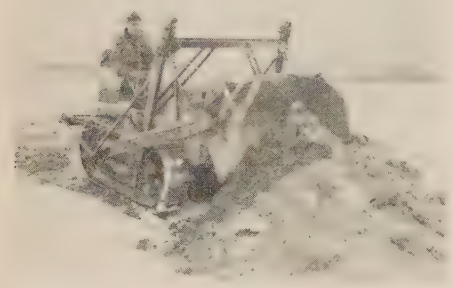
The accompanying illustration shows a new trench digger developed by the C. H. & E. division of the National Equipment Corp., Milwaukee, Wis. This outfit, which has been undergoing development for the past two years, will cut a trench from 3 to 6 in. wide and 4 ft. deep. Many uses for this machine in the water works and sewerage fields will suggest themselves. The bucket boom is operated by hydraulic lift, as in a motor truck, and the outfit is crawler-mounted. Two speeds forward and one reverse are provided. The machine will dig a trench 3 in. wide and 3 ft. deep at the rate of from 4 to 6 ft. per minute. Power is furnished by a 10-hp., 4-cylinder Fuller & Johnson engine.



New C. H. & E. Trench Digger

Miami Front-End Shovel for Caterpillar Tractors

A new piece of equipment produced by the Miami Trailer-Scraper Co., Troy, O., is the Miami front-end shovel for Caterpillar tractors, models 10, 15 and 20. This shovel is furnished complete,



Miami Front-End Shovel for Caterpillar Tractors

as illustrated, no extra tractor parts being required in setting up. Its capacity is 8 to 9 cu. ft. for the model 10, ½ yd. for the model 15 and ¾ yd. for the model 20.

The shovel is constructed of high-carbon plate, strongly reinforced by angle irons. The overhead cable-carrying frame is hinged to the tractor treads to equalize these treads in operation. The operating cables provide for an equal lift on each side beam. A short-circuiting device is provided so that the shovel may not be raised above a stated maximum height. The shovel bucket is dumped by means of a dumping lever and rope, the shovel then being lifted to its original position by a righting lever and rope.

The unit interchanges with the Miami bulldozer. In changing to bulldozer equipment it is necessary only to remove the two operating cables and four bolts where the shovel attaches to the extended axle in the tractor. The unit also interchanges with the Miami backfiller, providing excellent equipment for the contractor engaged in sewer or pipe-line work. Three power operations are available with a single tractor and power winch.

Py-Lubro in the Water-Works Field

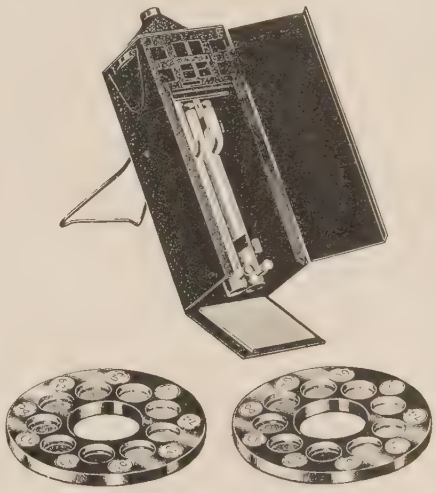
Py-Lubro is a compound recently introduced in the water-works field, especially prepared to prevent corrosion and to provide at the same time a lubricant to permit of instant separation or rotary movement of the parts so protected. Typical of its uses is the protection of a valve which, though seldom used, must be opened immediately when desired.

The corrosive action of water in distribution systems may be combated satisfactorily by the use of Py-Lubro on exposed frictional parts. According to the manufacturers, the Py-Lubro Co., Philadelphia, Pa., fire hydrants and valves assembled with Py-Lubro last longer and work easily. Packings well saturated with this compound may be depended upon to operate easily for a long period, it is stated.

Py-Lubro, the manufacturers state, is impervious to the weather and to heat, slow to break down under chemical action and equally slow to wear out under friction. It has the consistency of lard and is as easily applied as any grease.

Apparatus for Analysis of Water and Sewage

The accurate analysis of water, sewage and industrial wastes always has been an important factor for water and sanitary engineers. Until a short time ago the colorimetric tests were hindered by the inconvenience of preparing and rechecking the liquid comparison standards, which are said to fade more or less in the course of time. The accompanying illustration shows a water-test comparator with permanent color-glass standards, made by the Hellige-Klett Co., New York, N. Y.



Hellige Comparator and Glass Standards

The Hellige comparators for water analysis, hydrogen-ion control and many other tests have cells or tubes with plane and parallel walls and a prism arrangement which brings the color fields into juxtaposition. It is stated that working with these comparators is very simple and that tests can be made without any special training after a few minutes' reading of the directions. No readings from tables or calculations are necessary. The color disc is just revolved until a standard matches with the test solution and the result read directly by a number appearing through an opening in front of the apparatus.

In addition to the color-glass standards for the analysis of water, sewage and industrial wastes, permanent color-glass standards are available for hydrogen-ion control and many other tests.

New Traveling Water Screen

A new type of traveling water screen embodying many features has been put on the market by the Chain Belt Co., Milwaukee, Wis. While the general principle of traveling water screens is retained, the outward appearance of the screen itself has been definitely changed. It will occupy less space than heretofore. Another of its improvements is its accurate sealing and operating features.

The two major improvements consist of a new basket design and a new base.

These rectangular baskets hold the screen cloth (which may be of various constructions) and are in turn carried by two strands of Rex Chabelco hardened-steel roller chain. The chain operates over head and foot sprockets. As the submerged screen surface becomes matted with the refuse, the screen is revolved. The refuse is then lifted from the intake by the upward travel of the baskets and is automatically removed by means of a powerful spray of water directed through the baskets from their rear, which washes this refuse into a refuse trough. The spray of water serves to sluice the screen material away for disposal, usually on the downstream side of the plant.

The second major improvement is the radically new design of the foot wheel, which permits the use of the new extended track shoe. This shoe engages the roller at the exact instant that it leaves the wheel. There is no intervening space in which the roller can weave inward, causing openings between the ends of the baskets and the frame of the screen.

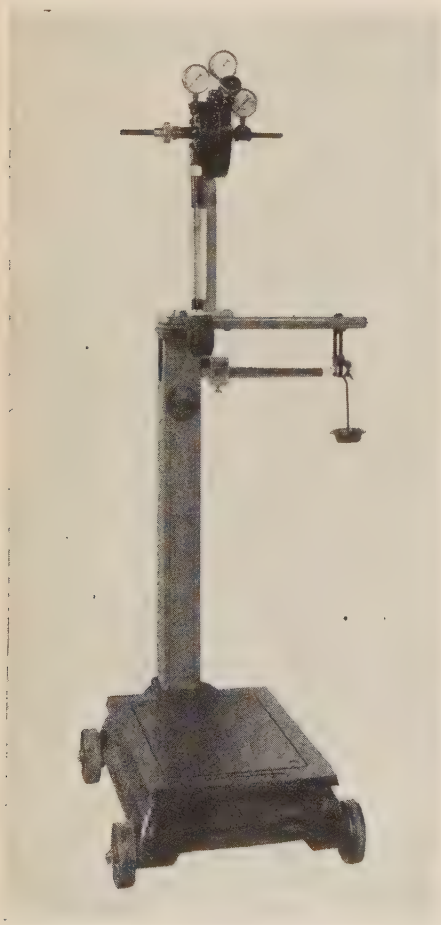
Chain Belt Traveling Water Screen

Pardee Ammonia Control Unit

The type 13 ammonia control unit manufactured by the Pardee Engineering Co., Long Island City, N. Y., is a device for controlling accurately the flow of anhydrous ammonia gas. It is easily adjusted to deliver the desired flow; once adjusted, it maintains this flow automatically until readjusted. Changes in supply or discharge pressure do not change the rate of flow through it. It consists essentially of a control valve which adjusts the flow, two diaphragm valves which maintain the flow and auxiliary gauges to aid in operation.

The total capacity range of this unit is from 0.02 to 200 lb. of ammonia a day. The capacity of a particular unit is limited by the meter in use. A bubbling meter covers the capacities from 0.02 to 1 lb. a day. Orifice meters with calibrated scales are provided for the larger sizes. Two or more orifices of different sizes can be had for the same unit. Meters are interchangeable, so that any unit can be changed to any capacity by inserting the proper orifice and scale and changing certain valve stems and seats.

The unit can be mounted on a short gray enameled stand attached to the arm of the platform scale on which the cylinders are placed. In addition, a gray enameled floor stand and a bracket for attachment to the wall or a pipe are available. This choice of mountings allows the unit to fit into nearly any plant condition.



Pardee Ammonia Control Unit

This unit is simple and strong. The different devices comprising it have been condensed into a single unit of few parts. Joints and connections have been reduced to a minimum. The gas flows continuously through every part of the apparatus. There are no dead ports or passageways to foul and plug up. Internal threads have been avoided wherever possible.

The unit is built of cast-iron and steel entirely. For the important valve parts, stainless steel is employed. The unit is finished in black pyroxyline enamel with chromium plating and polished trim. The scale is of white pyroxyline with black markings covered with pyroxyline. It will remain white and readable. The unit is easily operated and read, easily cleaned outside and in and easily maintained. Any good plant mechanic can take it apart and make replacements and repairs without danger of breakage or loss of accuracy. It will stand rough handling.

A New Self-Priming Pump

Much interesting development and research work has centered around a new self-priming centrifugal pump that the Chain Belt Co., Milwaukee, Wis., has recently put on the market. C. I. Longenecker, engineer for the company, who has spent the greater part of his life designing pumps, developed this new pump which, it is said, takes practically all the air out of the chambers and maintains its prime.

The new pump is in addition to the line of pumps the company now manufactures and is a part of the line of construction equipment consisting of concrete mixers, pavers, saw rigs, central mixing plants, etc. No matter whether the depth of the hole is 27 in. or 27 ft. and regardless of what the amount of water may be, the pump will keep its prime with greater lifting capacity. On many pumping jobs there are times when very little water is in the hole—in fact, barefuly a cupful. This may be the case one minute, and the next water may rush in and fill up the excavation. The pump used on the job must be ready to take care of the increase of water without any attention.

The new self-priming centrifugal requires no attention even though the water does go below the end of the hose. The vacuum is maintained automatically and the pump needs no priming. Just as soon as the water begins to drop the vacuum pump begins to exhaust the air and pick up the prime again. Ordinarily there are air pockets at the hub of the centrifugal vanes. These pockets interfere and many times destroy the prime. In the new self-priming centrifugal, Mr. Longenecker has made it possible to remove these air pockets before they can be sealed.

C. H. & E. Self-Priming Centrifugal Pump

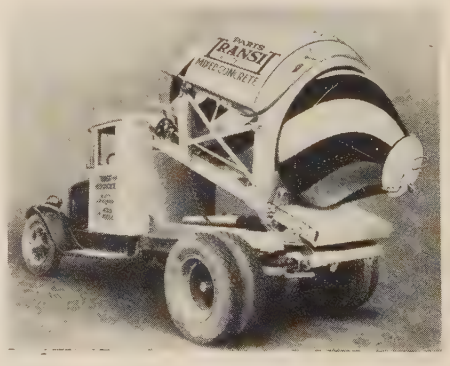
Transit System of Concrete Production

The Paris Transit concrete mixer, manufactured by Transit Mixers, Inc., San Francisco, Calif., consists of a revolving mixing drum, constructed to be mounted on a truck, deriving the power for rotating and tilting the drum from the truck engine.

The drum is cylindrical in shape, having a cone or apex end for receiving the components and discharging them mixed. The inside of the drum is provided with a series of baffle plates and bars, insuring a complete distribution of the mix as the drum rotates. Water tanks, consisting of one main tank and one reserve tank, are installed at the top of the mixer. The water is sprayed through a feeder piper in the center of the drum, and the volume is automatically controlled.

Transit mixers are built in sizes to suit standard makes of trucks and have capacities up to 5 cu. yd. Sizes to meet all weight restrictions, as well as the needs of any operator or community, are thus supplied.

Essentials in the Paris Transit system of concrete production are (1) proper provision for accurate measurement of aggregates and cement; (2) complete dry mixing of aggregates and cement; (3) a system for measuring accurately and adding an exact quantity of water, and a means of effecting a complete mixture of the whole; (4) a system of operations that will insure delivery of the completed mix exactly



Paris Transit Mixer

where, when and in the quantity wanted without segregation, and (5) a method of mixing while discharging that delivers the mix in perfect form for work—either in stiff or wet mix.

Lawrence Non-Clogging Sewage and Trash Pumps

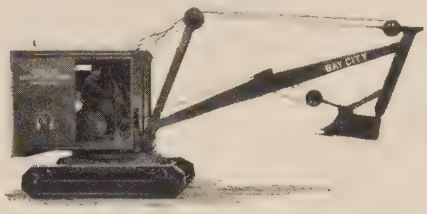
The accompanying illustration shows a Lawrence Vortex Sureflo non-clogging sewage and trash pump, manufactured by the Lawrence Pump & Engine Co., Lawrence, Mass. The special impeller design of this pump contributes to the satisfactory handling of large solids, trash, rags and stringy material without clogging and without screening. Large handholes are provided at the pump suction so that any material too large to enter the pump casing can be removed readily. Heavy construction throughout gives long life under severe operating conditions. This pump can be furnished with all parts coming in contact with the liquor handled made entirely of iron, bronze, monel metal or stainless steel. Special wear-resisting alloys are available for handling abrasive material.

This pump may be had in a horizontal model with the same special casing and impeller design.

Vertical Model of Lawrence Sureflo Non-Clogging Pump

Bay City Announces Special Trench-Type Boom

Bay City models R and K full-revolving machines are now available with special heavy-duty trenchoe equipment, with an electrically-welded boom. This construction is shown in the accompanying illustration. These machines have previously been constructed with a convertible skimmer-ditcher boom which could be used for the operation of either skimmer-type bucket or trenchoe. The manufacture of the convertible boom will not be discontinued and it will still be available for contractors who are doing both skimmer and ditcher work.



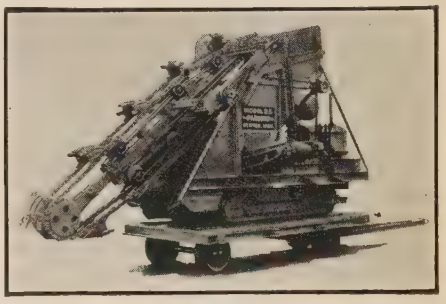
Bay City Model K with Special Trench Boom

The special type of trench boom illustrated is a better type of boom to use for trench work and will be furnished to purchasers who are interested primarily in trenching and open-ditch work. It cannot be used to operate a skimmer or any other bucket. When using the special trench-type boom as illustrated, it is possible to eliminate the extension mast which is necessary for skimmer work. The base of the special hoe boom is mountd on the unit cast revolving table. The semi-vertical mast is designed so that it can be reached or lowered to reduce the overhead clearance of the machine for passing under bridges, overhead railroad crossings, etc.

New Parsons Ditcher

A new ditcher, the model 25, for medium-sized jobs, built according to Parsons patented offset design on full-crawler traction, has been brought out by the Parsons Co., Newton, Iowa. This machine fits right into the Parsons line of patented offset-boom full-crawler machines—coming naturally between the 21, which is designated for lighter trench work, and the 31, which handles the heavier water and sewer jobs.

The 25 contains several advanced features which are claimed to be of particular advantage to a machine of this size:



Parsons Model 25 Ditcher

1. Two bucket speeds which, synchronized with the four traction speeds, enable the operator to show large output and save power.
2. Two speeds on conveyor, to adapt it to yardage load at various ranges of digging.
3. Full-crawler mounting on an improved three-point suspension.
4. Enclosed transmission with ground shafting, heat-treated gearing and roller bearings. This single transmission contains every operation, including traction speeds and reverse, conveyor drive and reverse, boom hoist and reverse, bucket drive and reverse—a compact working unit, fully protected in an oil-tight case.
5. Conveyor frame of extra heavy construction, to meet severe digging conditions.
6. Boom hoist through shaft equipped with flexible couplings and connected to pull directly on the roller carrying the boom carriage.

Because of its compactness, the Parsons 25 is easily handled and easily moved from job to job. Where jumps are long the machine rolls quickly up on to a trailer.

Page Drag Shovel Attachment

A 1½-yd. drag shovel recently announced by the Page Engineering Co., Chicago, Ill., brings a new tool to the service of the water-works contractor. This machine covers a radius of 55 ft., digs to a depth of 28 ft. and can dump into a hopper 20 ft. high. Although

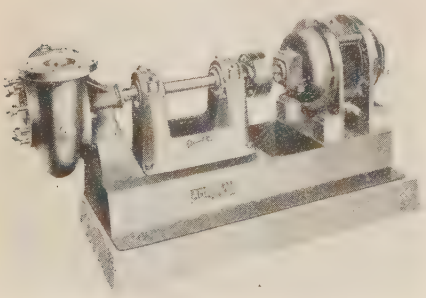
Page Walking Dragline with Page Drag Shovel Attachment on a Difficult Excavation Job

it digs with steam-shovel aggressiveness, it handles like a dragline, loading equally well above or below the machine level. The bucket is under close control and will carry a flat bottom in the deepest trench or grade a slope with precision, either toward the machine or away from it. It always gets a load, which it carries without spilling to the spoil bank, truck or car it may be loading. This product is offered as a standard attachment for several of the better known draglines from ½ to 2-yd. capacity.

The accompanying photograph shows a Page walking dragline with the Page drag shovel attachment at work for Dowdle Bros. on their contract for the Illinois Steel Corp., Chicago, Ill. The excavation for the footings of the new beam mill is through 18 ft. of heavy slag and furnace bottoms.

American Well Works Two-Port Sewage Pump

The American Well Works two-port sewage pump is a new departure in sewage-pump design. The two-port impeller with which these pumps are equipped permits the handling of unscreened sewage. This makes unnecessary the installation of expensive screens or the usual high maintenance cost necessary if screens are to retain their effectiveness. This pump is also appliacable for use in boosting raw sewage from low to higher levels, obviating expensive sewage construction in many instances.



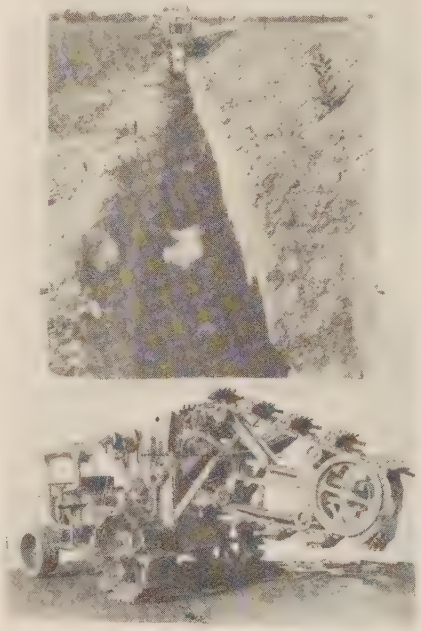
American Well Works Two-Port Sewage Pump

This pump is made in both vertical and horizontal types and in a wide range of sizes and capacities. Large hand holes are conveniently placed in the volute for the inspection of the interior of the pump, and thrust bearings of the ball-bearing type are provided. Vertical pumps are furnished either with or without steel framework, and are also furnished either with or without closed line shaft.

On vertical pumps the bearing immediately above the pump is of the split type. It may easily be removed, permitting access to the interior of the pump, without disturbing pipe connections.

Topping Pony Ditcher

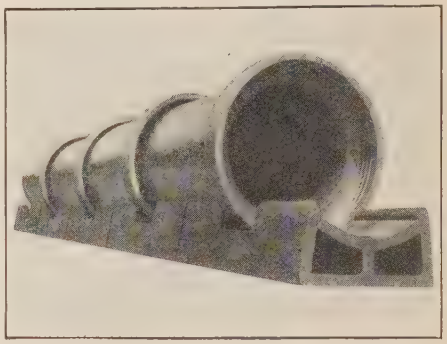
The Fordson model of the Topping pony ditcher is particularly well adapted to trenching for water lines, small sewers and other conduits of small dimensions. This machine replaces heavier and more cumbersome and costly ditching outfits, effecting desirable economies in work of the nature indicated. The Fordson power unit offers ample power for traction, digging and operation of the various levers. The machine has 17 forward speeds and 9 reverse. Only one man is required for operation. Many water-works boards have found it profitable to include Toppings among their equipment for use on small and large jobs. The Topping will dig trenches from 13 to 24 in. wide and up to 7 ft. deep.



Topping Ditcher: Close-Up and in Action

Ric-wiL Sewer Products

Ric-wiL cradle base for sewers is made of heavy vitrified tile in a design which supports and strengthens the sewer pipe. It is flat on the bottom, which is the full width of the pipe, and the top is shaped to cradle the pipe, with slots for the bells. It forms a solid foundation and grades, aligns and centers the pipe automatically. It gives effective drainage in wet going and is said to speed the work of installation materially. The design of the cradle adds an average of 82 per cent to the crushing strength of the pipe supported, the manufacturers state.



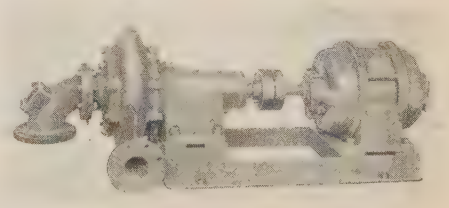
Ric-wiL Cradle Base

This cradle base is made for all diameters of sewer pipe, up to and including 18 in. It is made in 2-ft. sections for 2-ft. pipe, 15-in. sections for 2½-ft. pipe and 18-in. sections for 3-ft. pipe. Special sizes are available for larger pipe.

Ric-wiL sewer-joint compound is made from specially-selected asphalts, refined and blended. The lighter oils are removed and a powdered, acid-resisting filler is added. The mixture melts at moderate kettle heat and cools rapidly. According to the manufacturers, this compound assures watertight joints, preventing infiltration and conserving the full capacity of the pipe for sewage. The joints are flexible enough to conform to movement caused by settlement.

Worthington Freflo Pump for Unscreened Sewage

The Freflo ball-bearing centrifugal pump, placed on the market within the last few months by the Worthington Pump & Machinery Corp., Harrison, N. J., is designed especially to handle unscreened sewage.



Worthington Freflo Pump, Direct-Connected Horizontal Type

Among the important features of this design is the complete elimination of a stuffing box by the use of a sylphon air and water seal. This design reduces considerably the overhang of the shaft. The design of the impeller used in these pumps is original with Worthington and is based on the results of exhaustive tests. The impeller is of wide sections and will pass solids, trash and stringy material without clogging the pump. Standard impellers are made of cast iron, but impellers of bronze will be furnished when required by conditions.

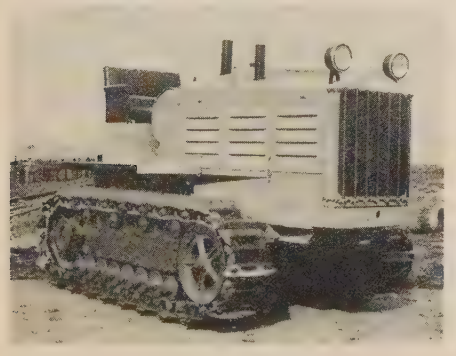
The Freflo pump is fully standardized, and many of the parts are interchangeable in pumps of different size and type. Arrangements for all the accepted methods of driving are provided: horizontal type for direct connection to electric motors or internal-combustion engines, belt drive from prime movers or line shaft and vertical shaft drive. The horizontal pumps for direct drive are mounted on structural steel base plates as shown in the illustration. The belt-driven pumps can be mounted directly on a concrete pedestal. Two arrangements are provided for vertical shaft drive, a self-contained unit with base elbow and a bracket as used on the horizontal model.

80-60 Cletrac a New Product

The new 80-60 Cletrac, a product of the Cleveland Tractor Co., Cleveland, O., was first shown to the public at the Atlantic City convention and show of the American Road Builders' Association last January.

The over-all width of the tractor over the track is 96 in. and the over-all length is 156 in. The height from ground to top of radiator is 82 in. The ground clearance between the lowest part of the drawbar and the ground is 15 in. without grousers; with grousers it is 18 in. The tread of tracks is 67 in. center to center; the width of tracks is 17 in. The width of grousers is 20 in. and the track length (ground contact) is 97 in. This gives a ground contact of 33 per cent of the total length of track.

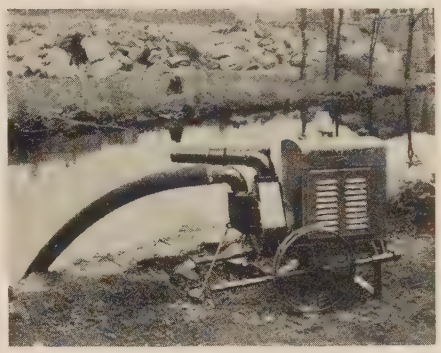
The 6-cylinder engine has a 5½-in. bore and a 6½-in. stroke, with 927 cu. in. displacement; it is governed at 1,050 r.p.m. It develops 119 b.hp. and 645 ft.-lb. torque. The engine is equipped with 12-volt Delco-Remy starting and lighting and single ignition, Purolator oil cleaner and A-C breather. The clutch is an 18-in. pull-type Borg & Beck. The transmission is of the selective type and gives three speeds forward and one reverse. At 1,050 r.p.m. engine speed the tractor speeds are 1¾ m.p.h. in low gear, 2½ m.p.h. in intermediate gear, 3.6 m.p.h. in high gear and 2.1 m.p.h. in reverse.



New 80-60 Cletrac

New 4-In., Self-Priming Homelite Pump

The Homelite Corp., Port Chester, N. Y., announces a new self-priming portable 4-in. centrifugal pumping unit with built-in gasoline engine.



New 4-In. Self-Priming Homelite Pump

As in other Homelite units, the pump is self-priming without the use of auxiliary pumps or vacuum apparatus. The pump capacity is 25,000 g.p.h. with suction lift of 20 ft. The bronze impeller is of the open type. Powered by a Le Roi 8-10-hp., 4-cylinder gasoline engine, the complete unit weighs 730 lb.

Buckeye Adds Larger Diesels to Line

For the past twenty years the Buckeye Machine Co., of Lima, O., has manufactured internal-combustion engines of the gas, gasoline and diesel type in various sizes. Because of the great demand for the larger diesels they now have added larger vertical diesels to this line.

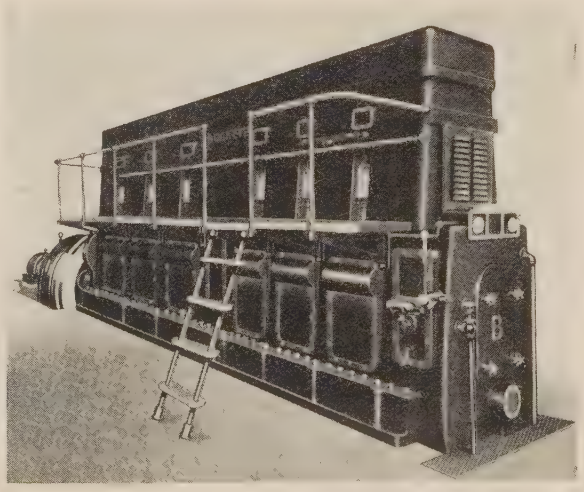
The vertical Buckeye operates on the four-stroke-cycle principle and is built in sizes of 200 hp. and up to 480 hp. in 3, 4, 5 and 6-cylinder units. The piston is 13 in. in diameter and has an 18-in. stroke, which develops 65 hp. per cylinder at 300 r.p.m.

Features of the engine are as follows: removable cylinder liners; new air intake, designed to give a highly turbulent cylinder charge; built-in air filters; fuel-oil filters and lubricating-oil filters. Cylinder heads are removable without disturbing exhaust manifolds, air pipes, springs, etc. Pressure lubrication is used throughout and all parts are fully enclosed, as can be seen in the illustration.

Automatic Primer Co. Products

The American chlorinator, recently introduced by the Automatic Primer Co., of Chicago, has already come into extensive use. It employs the dry-feed method, which has proved thoroughly satisfactory for the sterilization of water supplies, swimming pools, sewage, etc., the gas being fed from convenient cylinders of compressed chlorine through the chlorinator and a glass tube leading into the water-supply feed pipe or reservoir, as local conditions require. Features of the device are strength and simplicity of construction and a special measuring control designed for maximum accuracy and dependability.

Where the accumulation of gas or air hinders the flow of liquids, Apco automatic air-relief valves, made by the Automatic Primer Co., provide an inexpensive and efficient remedy. They seal on liquid, but pass gas both in and out, and are used to prevent binding in pumps, pipe-line summits and various types of tanks and vessels. These valves are made in three styles and a



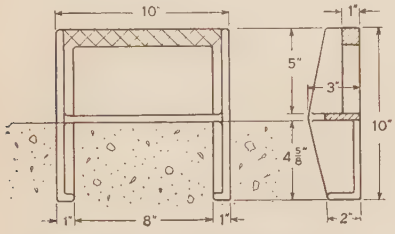
New Buckeye Vertical Diesel

complete range of sizes, for pressures of from 10 up to 500 lb., and for venting from 3 to 400 cu. ft. of gas per minute. Multiple installations take care of larger requirements. One model can be used advantageously on city water mains, as it is specially constructed for piping systems in which the gas to be vented collects in large quantities at pressures of 200 lb. or more.

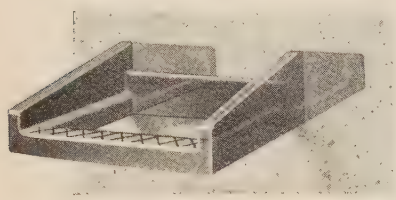
By inserting a vacuum ball in the head, any of the valves can be made to pass out but not in. All models are simple and compact, and operate continuously without attention.

New Clow Cast-Iron Manhole Step

A new product of James B. Clow & Sons, Chicago, Ill., is the A-1670 cast-iron manhole step, shown in the accompanying illustrations. This step was designed by a Chicago engineering firm, and is one which they recommend for use wherever a fixed means of ascent and descent is needed. These steps are made to be embedded in the vertical walls of sewer manholes, catch basins and valve and conduit manholes, and in all other vertical surfaces where dampness and the action of the elements are to be considered. This step can be affixed to either concrete or brick walls. The wide, flat, checkered tread provides a safe footing, while the raised sides prevent the foot from slipping off sidewise in either direction. Considering the long life of the steps and the factor of safety afforded, they find a wide application in the waterworks and sewerage fields.



Dimensions of Clow Manhole Step



Clow Cast-Iron Manhole Step

Chase Copper Tubing for Underground Service

A recent development of the Chase Brass & Copper Co., Waterbury, Conn., is Chase copper water tubing for underground service. The chief advantages claimed for copper water tubing for underground service are freedom from corrosion, and flexibility. There is no contamination of the water. The tubing is flexible and accommodates itself to unevenness and settlement of the soil. Chase tubing has been tested at water pressures up to 2,000 lb. per sq. in. in sizes up to ¾ in. and 1,500 lb. per sq. in. in larger sizes.

Copper service pipes may be installed by the average water department crew. Five tools are required for installation: a wrench, a hammer, a hack saw, a reaming knife and a flanging tool.

An installation is started by unrolling a coil of tubing. This is done by one man. After uncoiling the tubing it is straightened by hand and cut off at the desired length with a hack saw. The burred inside edge is reamed off, a slip nut is placed over the tubing and the end of the tubing is flanged with a Chase flanging tool and a hammer. The fitting is now screwed on to the slip nut. The trench can be filled in as quickly as the installation progresses without danger of injuring the tubing by settling of the ground. Difficult bends are accomplished easily without tools or bending devices. This is an advantage in cases where it is necessary to work around boulders, conduits or other obstacles in the trench.

A line of red-brass fittings for underground service is also manufactured by the Chase Brass & Copper Co.

H T H—Chlorine in Its Newest Form

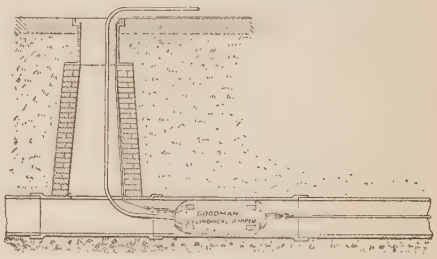
The Mathieson Alkali Works, Inc., New York, N. Y., announces the marketing of true calcium hypochlorite under the trade name H T H, a contraction of the term "high-test hypochlorite." This product is calcium hypochlorite in the form of a dry, stable, highly-concentrated powder. It has never been manufactured before in this country. The development of H T H marks the advent of chlorine in an entirely new form—a true hypochlorite containing 65 per cent available chlorine.

H T H, unlike chlorinated lime, is readily soluble in cold water. It gives up its available chlorine into solution quickly and completely, with a relatively small amount of quick-settling insoluble matter. This results from the fact that calcium hypochlorite itself is readily soluble, as is also the inert material (ordinary salt), while the calcium hydroxide content is very low and is in the form of free lime. The free-flowing character of H T H is also an important factor in its ready solubility.

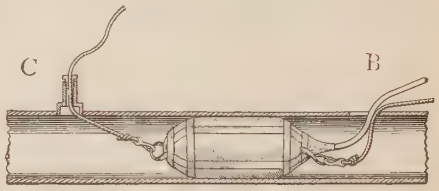
Many phases of municipal sanitation, such as the chlorination of wells and isolated water supplies, the chlorination of newly-laid pipe lines, etc., call for the use of chlorine in compact, concentrated form. H T H has proved a useful ally of liquid chlorine in this field where chlorination is carried on intermittently or on a smaller scale. Among even the larger water works it is sometimes desirable to have on hand a reserve supply of chlorine for use in case of an emergency. H T H is admirably suited to this purpose because of its stability and high concentration.

Goodman Safety Cylindrical Stopper

The accompanying illustrations show the use of the Goodman cylindrical stopper, manufactured by the Safety Gas Main Stopper Co., Brooklyn, N. Y., in sewer and pipe-line work. In sewer work the stopper is dropped into a manhole and allowed to drift with the stream to the desired point, where it is held by the rope and inflated until the flow is stopped. In a water pipe it is inserted through the two small tap-holes and inflated to the proper pressure. The complete operation, the manufacturers state, requires only 1 minute.



Use of Goodman Stopper in Sewer Work



Goodman Stopper in Water Line

Four-Wheel Utility Trailer

The accompanying illustration shows a four-wheel trailer manufactured by the Utility Supply Co., Clintonville, Wis. This trailer is of 5-ton capacity and weighs 4,400 lb. The height of the bolster bed from the ground is 43 in. Bolster stakes are adjustable to give 18 to 46-in. widths. The reach length is adjustable, with five adjustments from 12 to 28 ft. between bolsters. Wheels are of electric cast-steel; springs, front and rear, are semi-elliptic.

Four-Wheel Utility Trailer

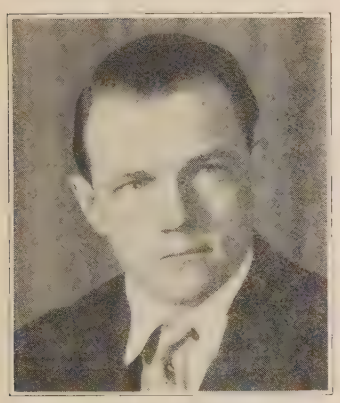
Who's Who

Among Manufacturers, Their Representatives and Distributors in the Field of Water Works and Sewerage

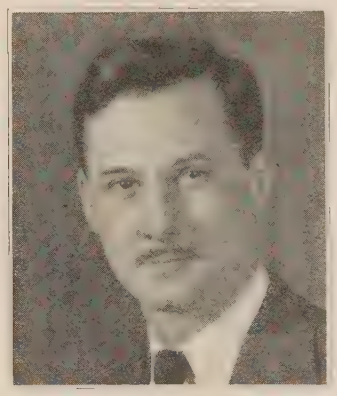
J. S. WILSON
Engineer San Francisco Office
American Rolling Mill Co.
Middletown, Ohio

R. C. BEAM
Engineer
American Rolling Mill Co.
Middletown, Ohio

J. C. BROWN
Engineer
American Rolling Mill Co.
Middletown, Ohio



E. C. BRAY
Engineer Philadelphia District
American Rolling Mill Co.
Middletown, Ohio



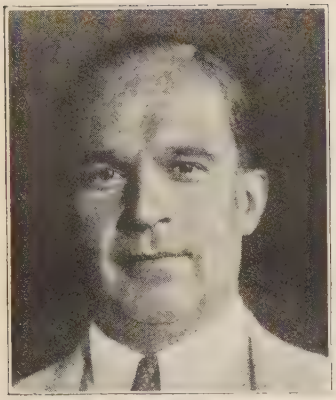
A. W. BRYANT
Engineer Detroit District
American Rolling Mill Co.
Middletown, Ohio

J. F. COHIG
Engineer Chicago District
American Rolling Mill Co.
Chicago

W. N. CROUT
Engineer Cleveland District
American Rolling Mill Co.
Middletown, Ohio

W. W. GRAHAM
Engineer Cincinnati District
American Rolling Mill Co.
Middletown, Ohio

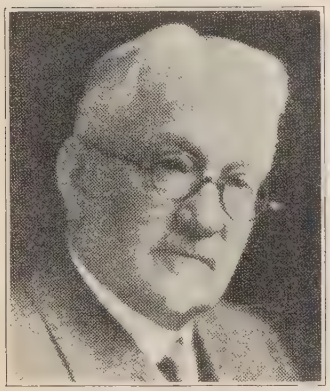
R. E. WALKER
Engineer Tulsa Office
American Rolling Mill Co.
Middletown, Ohio



H. S. JOHNSON
V. P. in Charge of Sales
American Hoist & Derrick Co.
St. Paul, Minn.

H. G. CHAPMAN
President
The American Well Works
Aurora, Ill.

R. B. CHAPMAN
Asst. Secy. and Asst. Treas.
The American Well Works
Aurora, Ill.

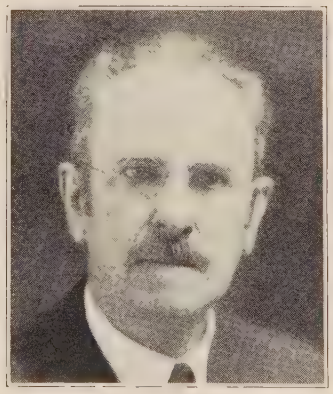


R. D. MAHAFFEY
Vice-Pres. and Treas.
The American Well Works
Aurora, Ill.

H. W. SPILLER
Secretary
The American Well Works
Aurora, Ill.

R. W. RUTH
Sales Manager
The American Well Works
Aurora, Ill.

GEORGE L. WIRTZ
Secretary
The Atlas Mineral Products Co. of Pa.
Mertztown, Pa.



M. F. WIRTZ
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The Atlas Mineral Products Co. of Pa.
Mertztown, Pa.

BEN H. BLACK
Sales Engineer
The Atlas Mineral Products Co. of Pa.
Mertztown, Pa.

C. W. FISHER
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Austin Machinery Corp.
Muskegon, Mich.

O. A. SEYFERTH
President
Austin Machinery Corp.
Muskegon, Mich.

FREDERICK H. BRADFORD
President
Automatic Primer Company
Chicago

ERIC W. BACHARACH
President
E. W. Bacharach & Company
Kansas City, Mo.

C. W. WRIGHT
President
Badger Meter Manufacturing Co.
Milwaukee, Wis.

E. M. KRUEGER
Chief Engineer
Badger Meter Manufacturing Co.
Milwaukee, Wis.

J. C. MILLER
Research Engineer
Badger Meter Manufacturing Co.
Milwaukee, Wis.

LUKE L. BALLARD
Vice-Pres. and Genl. Sales Mgr.
Badger Meter Manufacturing Co.
Milwaukee, Wis.

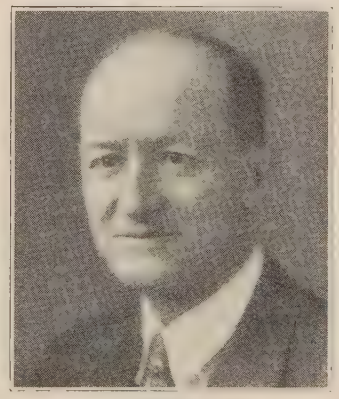
H. BUCHHOLZ
Secretary-Treasurer
Badger Meter Manufacturing Co.
Milwaukee, Wis.

B. E. LINDSTROM
Chicago Dist. Mgr. of Sales
Barber-Greene
Chicago

MORGAN RAMSAY
Sales Manager
Bay City Shovels, Inc.
Bay City, Mich.

ARTHUR W. BLAKE
President and Manager
W. L. Blake & Company
Portland, Maine

WILLIAM T. BIRCH
President
Birch Manufacturing Co.
Chicago



JAMES ASTON
Consulting Metallurgist
A. M. Byers Company
Pittsburgh, Pa.

THOMAS F. WOLFE
Research Engineer
Cast Iron Pipe Association
Chicago

DONALD M. CLARK
Secretary and Sales Mgr.
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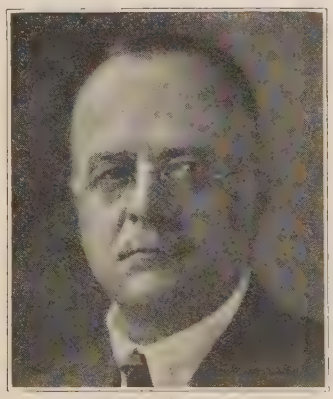

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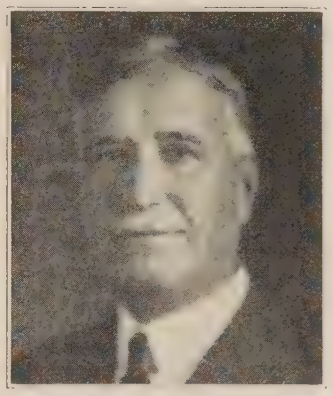

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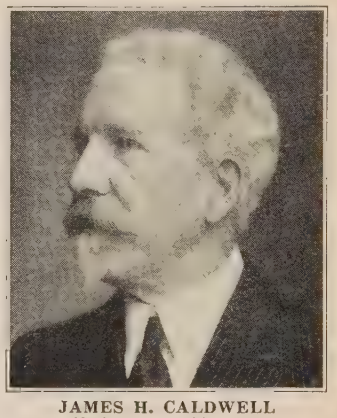

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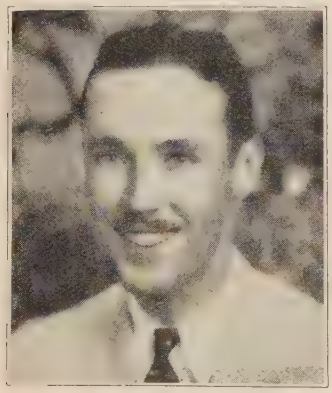

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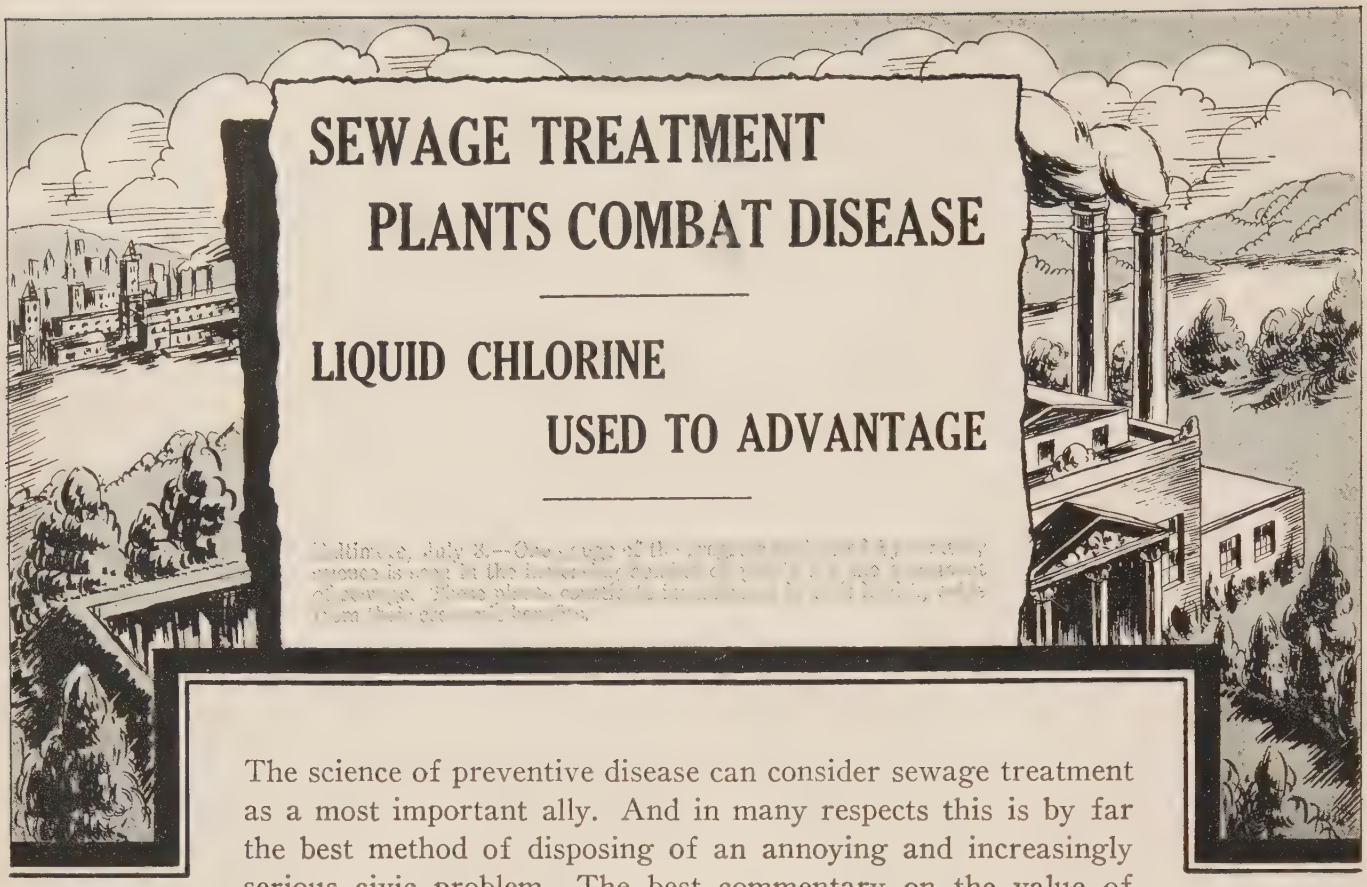
July, 1930

H. P. Gillette Editor

Vol. LXXVII. No. 7

Early Intake Diversion Dam of Hetch Hetchy Water Supply System of San Francisco, Calif.

MEMBER A. B. C. A. B. P.



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Vol. LXIX JULY, 1930 No. 7

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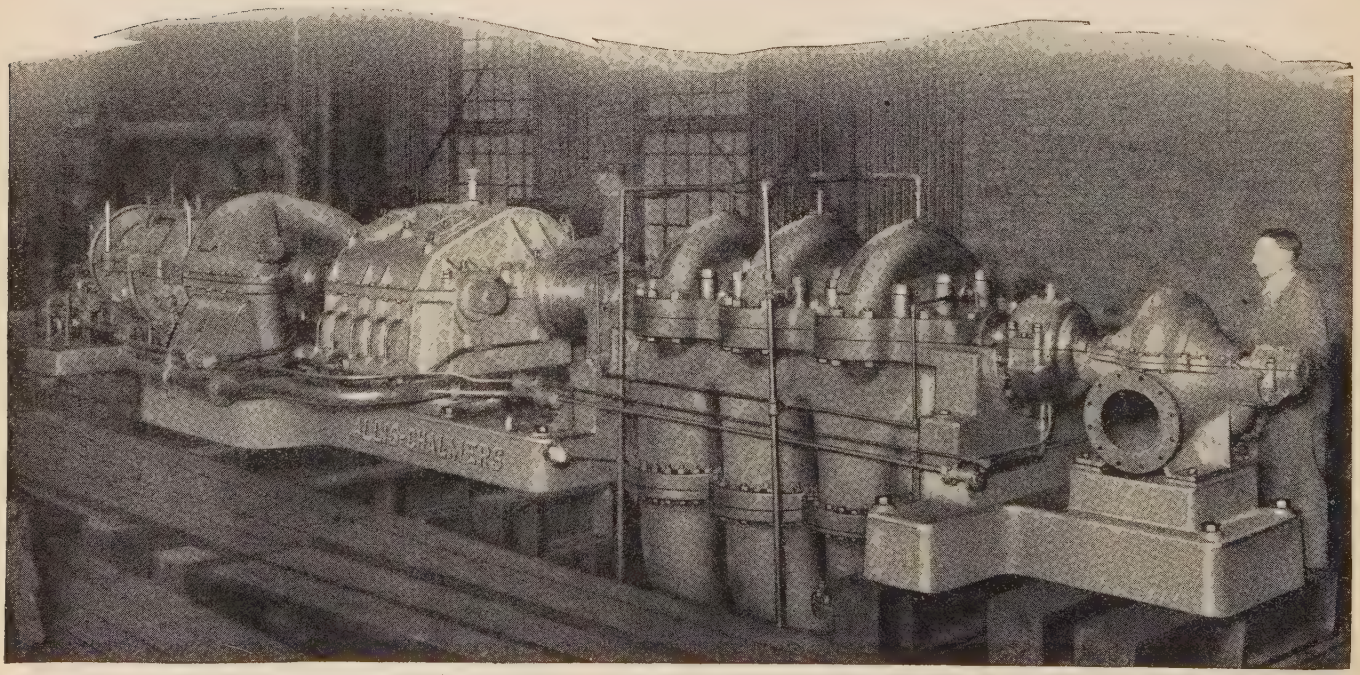

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Water Works and Sewerage

Vol. LXXVII JULY, 1930 No. 7

The Cobble Mountain Water Project of Springfield, Mass.

Construction Features of New $4,000,000 Water Supply Development of Springfield, Mass., Which Includes the Building of the Highest Hydraulic Fill Dam in the World

By JAMES B. PORTER

Assistant Chief Engineer, Water Department, Springfield, Mass.

SOME 25 years ago, the city of Springfield, Mass., selected the Little River as the source for its water supply and in 1908 and 1909 a system was constructed. This system included a storage reservoir at Borden Brook of 2,500,000,000 gal. capacity, a diversion dam on the Little River some five miles below the reservoir, a tunnel 6 ft. 3 in. by 5 ft. some 4,500 ft. long through the mountain to the filter beds, a sedimentation basin with a capacity of about 40,000,000 gal., about three acres of slow sand filters, about 7½ miles of 42-in. lockbar pipe from the filters to a pure water reservoir at Provin Mountain which has a capacity of about 17,000,000 gal., about 4½ miles of 42-in. lockbar pipe from this reservoir to the Connecticut River and two 30-in. lockbar pipes across the river. At this time the system was designed to carry the city for 25 or 30 years, but studies were made for the ultimate development of the watershed and a tentative location selected for the Cobble Mountain Dam.

Hydraulic Giants Operating in Borrow

Mud and Water Lines at 1930 Borrow; Cobble Mountain in Background

Springfield has a population of about 150,000 and supplies water to several of the neighboring towns. The total population furnished water from this supply in whole or in part is about 250,000 and the average daily use about 18 M.G.D.

General Features of New Supply.—In 1924 construction was started on enlargement of the system and in the fall of that year Mr. H. H. Hatch was engaged to make the preliminary surveys for the dam and reservoir. He has been at work since that time on the surveys and the construction of the several works embraced in the complete project.

The dam and reservoir are situated on the Little River about 20 miles west of Springfield in a rough, mountainous section. The water shed is steep and impervious without much ground storage. Nearly 70 per cent of the yearly run off takes place in a few weeks each year. The catchment area is about 46 square miles with a mean annual rainfall of 48 in. and an average run off

General View, Looking East, of Dam Site of Cobble Mountain Hydraulic Fill Dam

at the dam site of about 58 M.G.D., which will probably suffice for the needs of Springfield for the next 50 years.

The cost of the Cobble Mountain project for water supply alone would have been about $4,000,000. This with the amount already invested would have made a rather heavy burden for the city, but the location of the new dam made possible a power development at an additional cost of some $2,000,000. The Cobble Mountain Reservoir will have a flow line at Elevation 952 and it was found feasible to develop a maximum head of 450 ft. at a distance of about 1½ miles down stream. A contract was made with the Turners Falls Power & Electric Co. to take this power at an annual rental of $270,000 for 30 years. With this annual rental to help pay interest and sinking fund charges, the project became feasible and the city was able to develop this watershed to its full capacity for water supply and at the end of the thirty years own the power station also. The power company will use this plant as an auxiliary for its entire system during peak loads and during the dry seasons and for some time be able to avoid the use of their present auxiliary steam plants.

What the Cobble Mountain Project Comprises.—The Cobble Mountain project includes a diversion tunnel, the dam, reservoir, spillway, two gate houses, the power tunnel, three penstock lines with surge tank, the power house and seven highways. The reservoir will have a capacity of 22.5 billion gallons, has an area of 1,120 acres, a maximum depth of 207 ft. and an average depth of 58 ft. The length of the flow line with the reservoir full is about 20 miles. For several years the city has been acquiring land for the reservoir site and on the watershed adjoining it and nows owns about 11,000 acres on the watershed.

The site of the dam in the narrow gorge of the Little River on the north slope of Cobble Mountain is ideal. Within the limits of the dam and near its upper toe the gorge makes nearly a right angle bend. The bottom and both sides are on solid ledge of mica schist, a characteristic rock of this section.

The dam site was inaccessible, so the first step in the project was the construction of a road about three miles long northerly from the dam site to the State highway. This was built with city forces by the division engineer during the time the preliminary surveys and investigations were being made for the whole project. When the project is completed, this road will be finished, extended across the top of the dam and be connected to other highways. Several other highways which will be flooded have been or are to be relocated and built at a cost of about $350,000.

The Diversion Tunnel.—After this first highway was built, a contract was let by the city to Coleman Bros. of Boston, Mass., for the construction of the diversion tunnel and the diversion dam. The diversion tunnel will take care of the river flow during construction. It is horse-shoe shaped with an area equivalent to that of a circle of 12 ft. diameter and was designed to carry 4,000 second feet. It is about 1,600 ft. long and has a shaft near its upper end over 200 ft. deep. Both shaft and tunnel are lined with concrete and were grouted to insure against any possibility of leakage. They are both entirely in solid ledge. After the main dam is completed, the upper end of the tunnel will be plugged with concrete through which will be laid two 42-in. pipes with gates. These pipes will have a capacity of about 1,000 second feet and will be opened in case of extreme floods or when the power company has drawn the water down to the elevation of the power tunnel. The elevation of the diversion tunnel is 754 and that of the power tunnel is 830. This leaves about 1½ million gallons of water below the power tunnel which will insure the ability of the city to carry over a long dry period after the power company has drawn all the water possible for power purposes.

The cost of this tunnel was about $330,000.

The Diversion Dam.—The diversion dam is located about 1,000 ft. downstream from the diversion tunnel. It is about 75 ft. high, 240 ft. long on top and 70 ft. long at the base. It has a top width of 40 ft. and a bottom width of about 300 ft. It was built of muck from the diversion tunnel as far as was possible. The upstream face of this

General View to Northeast Showing Core Pool, East Beach, Rock Fill, Concrete Toe Dam, Mud and Water Lines and 1930 Borrow Near Top

dam is of rolled embankment 10 ft. thick at the top and about 25 ft. thick at the bottom. This was designed to stop the leakage through the rock fill during the construction of the main dam. This dam was so located that it will form the upstream toe of the main dam and its top will be a berm on the upper face of the main dam. The total cost of the structure was about $60,000.

The Cobble Mountain Dam.—When the diversion dam and tunnel were about completed, the city received bids for the main dam and reservoir and the power tunnel. The contract for the dam, etc., was let to the Winston Co. of Kingston, N. Y., and the power tunnel to the Frazier-Davis Co. of St. Louis, Mo.

The Cobble Mountain Dam when completed will be the highest hydraulic fill dam in the world. It will have a maximum height of over 255 ft. from the bottom of the cut off wall trench and a height of 235 ft. in the center above the original stream bed. It will be 50 ft. wide at the top and over 1,500 ft. wide at the base, 700 ft. long on top and only 80 ft. long at the bottom. Due to the narrowness of the gorge and the very steep side slopes, it will contain only 1,800,000 cu. yd. of material, of which about 400,000 cu. yd. will be rock.

Site of Spillway Looking East from Near Where Spillway Bridge Will Be Located

Inlet to Diversion Tunnel

Before the contract for the dam was let, test tunnels were driven at right angles to the stream on both sides of it for a distance of about 80 ft. on one side and about 40 ft. on the other. These were driven near the center line of the dam to make certain of the character of the foundation rock.

In the bottom of the dam at the core section for a width of 270 ft. all material was excavated to the solid ledge, in some places to a depth of 15 ft. below the stream bed; also on each slope an area varying in width from 80 ft. at the bottom to 20 ft. near the top was similarly excavated.

In the bottom of the dam is a concrete cut-off wall 3x8 ft. which extends up both slopes to a point above the flow line. This was built in a trench in the ledge which is at least 5 ft. at every point below the surface of the rock. A second cut-off wall of the same dimension built into the rock in the same manner extends across the bottom and to a height of about 40 ft. up each slope.

Grout pipes are left in the cut-off walls and the rock will be thoroughly grouted before the fill reaches them. In the bottom of the dam these grout holes were 15 ft. deep and spaced 10 ft. apart all along the cut-off walls, which are 30 ft. apart. The depth of the holes was measured from the bottom of the foundation trench.

Concrete Dam at Downstream Toe.—In the original design of the dam there was not much rock in the lower toe and a concrete arch dam was designed to hold it and also to prevent erosion at

View Looking South Across Core Pool; Shows Cutoff Wall and Trench

any time by the water from the diversion tunnel which empties into the stream near this dam. Considerably more rock has been added to the lower toe, so that this dam has lost some of its importance, but it was decided to leave it as further assurance of the stability of the whole structure.

This dam is a concrete arch of about 100-ft. radius with a width of 14 ft. on top. The upstream face is vertical and the downstream face is battered ¼ to 1. The height above the river bed is 35 ft. The foundation without batter was carried down about 15 ft. below the stream bed to solid ledge. The length is about 200 ft. and the total yardage about 3,800. Its foundation is solid ledge, but is not grouted. There are three weep holes, each 4x6 ft. in the bottom to take the drainage from the lower rock fill, which has a considerable area and hence quite a run-off. The total cost of this structure was about $75,000.

Rock Fill.—Hydraulic fill dams require great care in their construction. The core which will ultimately act as the real water stop requires special care until it becomes thoroughly solidified. Some cores have taken years to solidify, but eventually have solidified into almost an artificial rock. During its semi-liquid condition the core exerts an hydrostatic pressure which on account of its heavier specific gravity will be greater than that of water. Therefore it requires support until it drains out and becomes a solid. The supports for the core are the beaches, which in turn are supported by the rock fills, which also add greatly to the weight of the body of the dam and increase its resistance after construction. In the Cobble Mountain dam there will be about 400,000 cu. yd. of rock fill or about 22 per cent of its volume. These rock fills occupy about 36 per cent of the area of the base.

Rock for these fills was obtained from several sources—from the excavation from the cut-off trenches, from the slopes, some 40,000 yd. from the spillway excavation, etc., but there were some 200,000 yd. left to borrow.

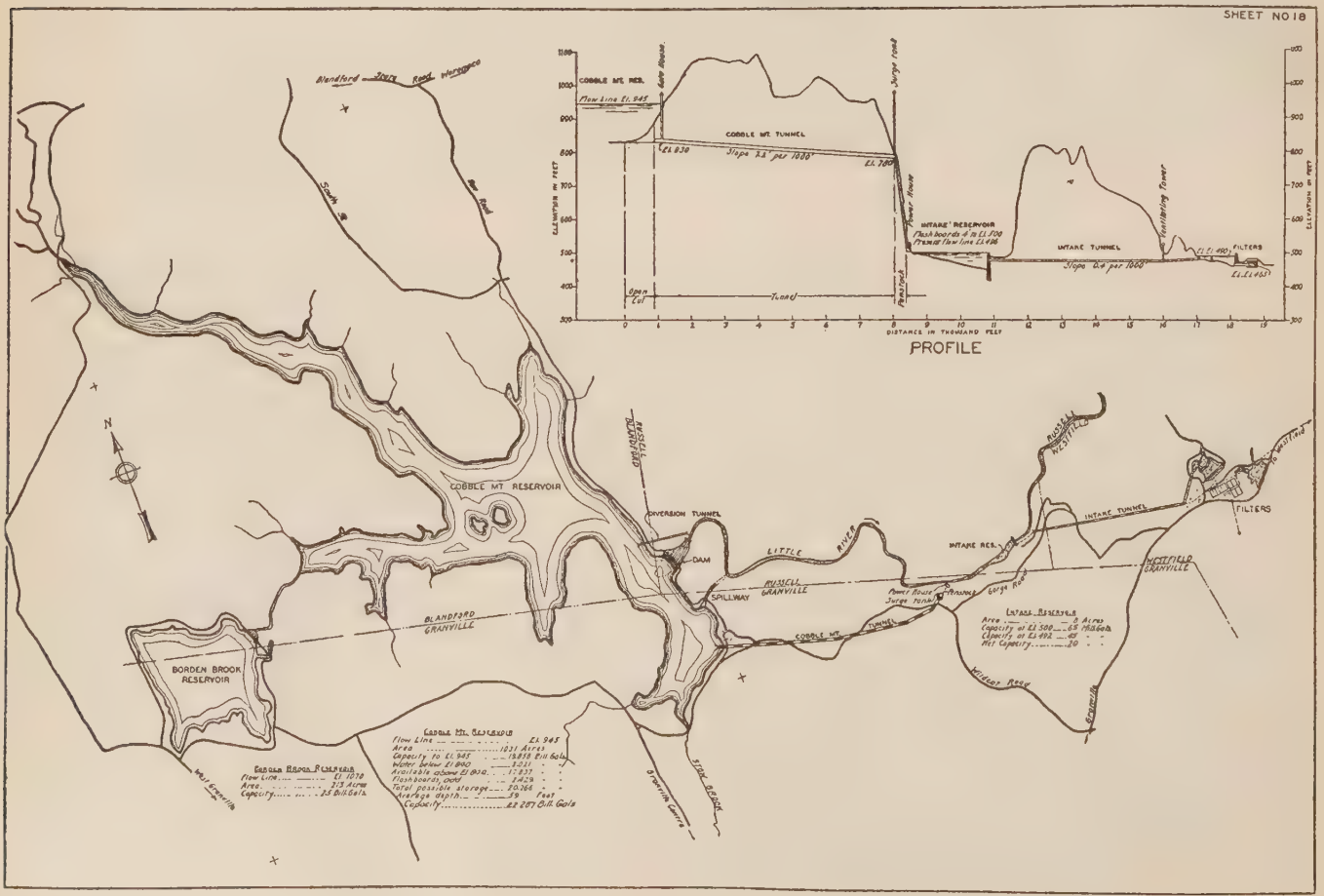
Quarries were established above the dam on both sides, the hills tunneled and shot. Much of the rock being blown into the location of the rock fills did not have to be rehandled. Seven tunnels were driven with an aggregate length of 1,012 ft.

The Hydraulic Fill.—The contractor originally figured on building the dam by the semi-hydraulic fill method, but changed to hydraulic fill before sluicing started.

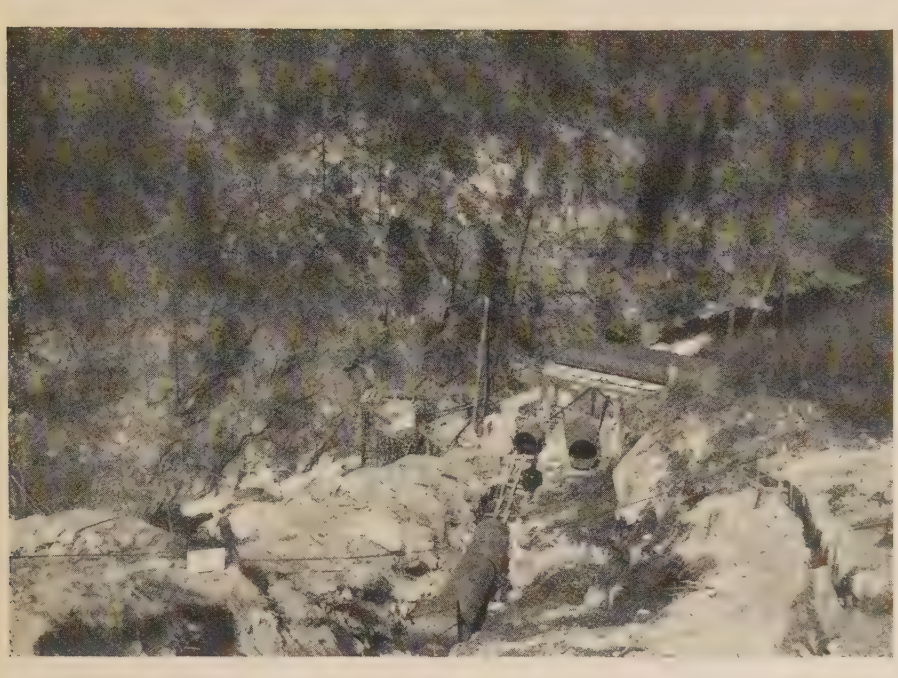
The hydraulic fill was started last fall, but early cold weather made a shut-down necessary soon after the start and only 125,000 yd. were placed. However, this gave considerable information as to what additional equipment would be necessary to complete the fill in the 1930 season. This additional equipment has been bought and work for the season is now in full swing.

As the dam is being built on the stream which supplies the water to the city only about four miles above the filters and some paper mills are located a few miles below on the same stream, the contractor cannot waste the water from the pool into the stream. This waste would be the muddy water containing very fine particles which would plug the city filters and greatly increase the cost of operation and possibly make operation impossible with the present filter area and also it would make impossible the use of the water by the paper mills and involve the city in expensive lawsuits. So the contractor must use the water in the pool over and over again. To do this a second pool has been made extending from just below the diversion tunnel to the upper toe of the main dam. Stow Brook, one of the tributaries of the Little River, empties into this pool and will probably furnish enough water to take care of the loss by evaporation and the seepage through the lower toe of the dam. If this is not sufficient, additional water will be secured from the main stream.

To the spectator the operation at the dam is very simple. The rock is handled into place with shovels and trucks. Material from the beaches is placed against the rock fill with drag lines; a floating pump pumps the water out



Plan Showing Water Supply Developments of Springfield As They Will Be After Present Work Now Under Construction is Completed



View Looking East at Penstocks and Power House

of the pool, keeping it at the required level; another pump pumps the water to the giants in the borrows; the stream from the giants is directed against the bank and the material washed into the sluice pipes; the outlet of the sluice pipes is changed to get the fill where desired; shear boards prevent the washing of channels in the beaches and the water finds its way to the pool to be pumped out again and again sent over the same course.

As the flow from the sluice pipes runs down the beaches the coarse material drops first and then the next coarser and so on. When the flow strikes the edge of the pool the larger particles still suspended in the water immediately sink and only the very fine ones remain suspended. At this point the riffle forms and the core limits begin, so the water in the pool must be kept at the proper elevation and the core built as designed.

The borrow pit used last fall was only about 800 to 1,000 ft. above the upper toe of the dam. On account of the large number of boulders it proved too shallow to work and a new borrow pit downstream from the dam and to the north of the river has been opened up this spring.

The material is excavated by giants having 5-in. nozzles under a nozzle pressure of about 100 lb. It then runs down to a head box which is fitted with a grizzly and there taken into the mud line which runs to the dam.

The Spillway.—The spillway is located in a natural gorge on the opposite side of Cobble Mountain from the dam. It is nearly parallel to the stream bed in the dam, about 240 ft. above it and about 1,400 ft. southerly. It has ample capacity. The highest known flood on the Little River was about 130 second feet per square mile of water shed and the spillway will care for over 400 second feet per square mile of watershed. A model—50 to 1—of the spillway as originally designed was made at the field office and some changes made to give the maximum discharge. Three models were built and the last one checked the computed discharge. With this large capacity and a 20-ft. free board on the dam there can never be danger of the dam overtopping.

The crest of the spillway is Elevation 945. Its width is 135 ft. at the mouth, narrowing down to 50 ft. in 200 ft. with a drop there of about 17 ft. From this point on the slope is 1 per cent to the end of the spillway channel with a uniform width of 50 ft. at the bottom and ¼ to 1 side slopes. The channel from the crest to the end is about 720 ft. and it ends about 260 ft. above the river bed at a point about 3,000 ft. below the concrete dam at the lower toe of the main dam. The maximum cut in the spillway was 55 ft. and the rock excavation about 56,000 cu. yd.

A reinforced concrete arch bridge will be built over the spillway which will carry the same highway that goes over the top of the dam.

The contract price of the dam, reservoir, etc., was $1,437,000.

The Laboratory.—The laboratory which has been established at the engineer's camp is probably the most complete of any ever established on the site of a job. It includes cement testing apparatus and also apparatus for analyzing the materials in the core.

The specifications for the core require that 10 per cent must be under 0.01 mm. No sieve for these sizes is practicable nor are any made. A method for core analysis has been perfected which gives a satisfactory degree of accuracy in determining sizes of such small diameter. The analysis down to the 200 mesh sieve is carried on after the usual method and from there on the principle of elutriation based on Stoke's Law is used. The sizes are computed and the results checked by microscopic examination.

Other tests for turbidity, settling, percolation, capillary, etc., are also made.

The Power Tunnel.—The power tunnel is being built by the Frazier-Davis Co. of St. Louis, Mo. It is horse shoe shape in section 9 ft. 4 in. high by 10 ft. wide and is about 7,100 ft. long. It will be lined throughout with concrete and grouted. Its purpose is to carry the water through the mountain to the penstocks which lead to the power house. The contract price for the tunnel is $651,000.

Sluicing Onto East Beach

The Surge Tank and Penstock Lines.—At the lower end of the power tunnel a surge tank will be erected. It is to be 25 ft. diameter and about 225 ft. high. Under it the pipe from the power tunnel will be divided in a mainfold into two 8-ft. and one 6-ft. steel penstocks which will carry the water to the power house at the upper end of the diversion dam basin. The steel work for the surge tank and penstock lines is being erected by the Walsh Holyoke Steam Boiler Works of Holyoke, Mass., under a contract with the Turners Falls Power & Electric Co. The penstocks are flange steel with longitudinal seams welded with a G. E. arc welding machine and the round-abouts are riveted.

The Power House.—The power house, which is the last unit of the entire project, is being built by Daniel O'Connell's Sons of Holyoke, Mass., under contract with the Turners Falls Power & Electric Co. It is of brick. It will have a capacity of about 33,000 kva. under an average head of 420 ft. The maximum head will be 450 ft. and the minimum head 330 ft. In it will be installed two 13,650 kw. and one 5,750 kw. units. Its estimated cost, together with the surge tank and penstocks, is $1,100,000. Its average annual output is estimated to be 22,000,000 kw. hour which will be transmitted to Westfield at 66,000 v. and then delivered to the company's system. It will add 23,000 kw. of capacity to their system.

Personnel.—The entire Cobble Mountain project with the exception of the surge tank, penstocks and power house is being built by the Board of Water Commissioners of the City of Springfield, Mass. Mr. E. E. Lochridge is Chief Engineer, Hazen and Everett are the Consulting Engineers and Mr. H. H. Hatch has been the Division Engineer in charge of all the preliminary and construction work. The surge tank, penstock lines and the power house are being built by the Turners Falls Power & Electric Co. under contract with the city. On their work Mr. H. M. Turner of Boston is the Consulting Engineer and Mr. H. A. Moody, Hydraulic Engineer for the company, has charge of the construction.

Filtration Plant Operations at St. Paul, Minn.

Some interesting information on the operation of the water works of St. Paul, Minn., in 1929 is given in the recently issued report of the Board of Water Commissioners, of which Leonard N. Thompson is general superintendent and engineer. The following notes on the operation of the water purification works are extracted from the report.

The year 1929 witnessed the peak of water treated and purified since the plant has been in operation. The maximum month was August, with a total of 873 millions, while the minimum month was February, with 591 millions of gallons. The volume of water for the month of August exceeded that of February by 8 per cent, when reduced to months of equal length, 34 per cent.

Table I—Comparison of Average Analyses of Water from the River, Plant Influent and Plant Effluent

Determination	Mississippi River p.p.m.	Plant Influent p.p.m.	Plant Effluent p.p.m.	Storage in Lakes Percentage Gain	Storage in Lakes Percentage Loss	Storage and Treatment in Plant Percentage Gain	Storage and Treatment in Plant Percentage Loss
Temperature C	11.5	10.7	11.1	.....	6.95	.....	3.48
Turbidity	7.2	5.8	0.0	.....	19.50	.....	100.00
Color	34.1	33.7	12.1	.....	17.70	.....	64.5
Odor at 90 C	2.84	2.74	0.48	.....	3.52	.....	83.2
Ammonia Nitrogen—N	0.0767	0.0629	0.0646	.....	18.00	.....	15.8
Albuminoid Ammonia—N	0.0215	0.0267	0.0170	24.2	.....	.....	15.8
Nitrite Nitrogen—N	0.004	0.002	0.001	.....	50.0	.....	75.0
Nitrate Nitrogen—N	0.089	0.090	0.068	3.4	.....	.....	23.6
Oxygen Consumed	10.8	10.9	8.1	0.9	.....	.....	25.0
"H"ion—pH	7.23	7.23	6.94	.....	.....	.....	4.0
Alkalinity—Phenolphthalein	3.50	4.2	.....	20.0	.....	.....	100.0
Alkalinity—Methyl Orange	153.0	139.0	126.0	.....	9.2	.....	17.7
Free Carbon Dioxide	0.92	0.04	2.84	.....	95.7	209.0	.....
Dissolved Oxygen	9.08	9.93	9.38	9.36	.....	3.3	.....
Residue on Evaporation 110 C.	206.0	179.0	187.0	.....	13.2	.....	9.2
Loss on Ignition	89.5	88.4	81.9	.....	1.23	.....	8.5
Non-Volatile Salts	116.0	96.0	105.0	.....	17.7	.....	9.7
Silicon Oxide	6.12	2.90	2.12	.....	52.3	.....	65.4
Iron Oxide—Fe_2O_3	0.654	0.240	0.126	.....	62.7	.....	80.8
Aluminium Oxide—Al_2O_3	1.346	1.127	1.133	.....	16.28	.....	15.85
Chlorine—NaCl	2.44	2.29	3.68	.....	6.15	50.80	.....
Calcium Carbonate—$CaCO_3$	90.0	89.0	89.0	.....	1.45	.....	1.11
Magnesium Carbonate—$MgCO_3$	49.0	48.0	47.0	.....	3.25	.....	4.47
Sulphur—$CaSO_4$	13.22	13.00	27.30	.....	1.67	106.0	.....
Manganese—Mn	0.098	0.053	.....	.....	46.9	.....	100.0
Temporary Hardness	135.0	132.0	117.0	.....	2.37	.....	13.3
Permanent Hardness	13.3	12.9	27.2	.....	3.0	105.0	.....
Total Hardness	149.0	145.0	144.0	.....	2.49	.....	3.2

The water used for backwashing the filters increased 37 per cent over water used for the same purpose, year of 1928. The increase may be attributed to two things: First, the mechanical condition of the plant; and, second, the condition of the plant influent as influenced by the presence of micro-organisms. The weather conditions were of such nature this year that the micro-organisms flourished for a long period both in the spring and in the autumn seasons.

The aluminum sulphate has been reduced 1¼ per cent compared to 1928, and 48.3 per cent compared to 1927. The total application for the year 1929 averaged 20.69 parts per million.

The average dosage of liquid chlorine increased 7 per cent for the year as compared to 1928.

Table I is a summary of all chemical data. The data show the relation between the chemical analysis of the water as taken from the Mississippi River, plant influent, and plant effluent. Columns 4 and 5 of the table show the percentage gain or loss effected by storage in the lakes, and by storage in the lakes plus water purification treatment. In general the products dissolved in the water are reduced by travel through the lake system, and by water purification treatment. In some few cases the data show a gain in dissolved material by traveling from the river through the lakes or by purification treatment. Albuminoid ammonia nitrogen increased 24 per cent during travel through the lake system. The material is probably contributed by decomposition of organic material such as weeds, and other debris in the lake.

Nitrate nitrogen gained 3.4 per cent. Oxygen consumed or oxygen consuming power of the water increased slightly during the passage of the water through the lake system. The oxygen consuming power is a crude measurement of the less readily digestible carbohydrates—refuse from plants. The weed growth in the lakes likely contributes the material to keep this factor on the increase as the water passes through the lake system.

The chlorine content of the plant effluent shows an increase of 51 per cent over that of the river. The increase is due to the liquid chlorine applied to the water for the purpose of sterilization.

Phenolphthalein alkalinity shows a gain of 20 per cent in the plant influent over that of the river water. Phenolphthalein alkalinity is increased in the lakes by the activity of the algae. The algae in process of growth extract the carbon dioxide from the bicarbonates of the water, leaving normal carbonates (phenolphthalein alkalinity).

Free carbon dioxide increased 209 per cent in the purified and treated water. The increase is due to the reaction of the aluminum sulphate with the bicarbonates liberating free carbonic acid.

Sulphur increased 106 per cent in the plant effluent compared to water as taken from the river. The increase is due to the sulphur added to the water in the form of aluminium sulphate. The aluminium changes to a "floc" and is removed, but the sulphur as sulphate ties up with the calcium and remains in the water.

Securing Suggestions for Bettering Public Service.—The city manager of Cincinnati enclosed with each water bill recently mailed to citizens a postcard asking for suggestions as to how to better the public service. Several thousands of them were returned with helpful replies.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Filtration Engineer, Bureau of Engineering, Chicago, Ill.

Water Purification Problems Discussed at the St. Louis Convention of the American Water Works Association

THE Fiftieth Annual Convention of the American Water Works Association, which was held at the New Hotel Jefferson in St. Louis June 2nd to 6th, was a very successful one. If judged by the number of excellent papers and discussions which were presented, it was the best convention ever held by the Association.

The Water Purification Division, formerly the Chemical and Bacteriological Section, presented a program of unusual interest. This division had its origin in 1913 as a section of the association, and while its activities were somewhat suppressed by the association for a few years, it began its rapid growth about 1920. Since that date no specialized group of any professional organization has grown in importance more rapidly. As though it was a great research institution for studying water purification problems, it has become the means by which most of the information worked out by those engaged in the design or operation of water purification plants becomes public and the knowledge transmitted from one to another. The groups of two, three or more who gather together in the lobby of the hotel, in the exhibition booths, or at other convenient points to discuss various problems connected with their work are probably of equal importance to the scheduled papers and discussions.

If there are those who still have doubt as to the value of the research worker in water purification, they could not have listened to the papers and discussions presented by members of the Water Purification Division at St. Louis without being impressed that research is bringing us nearer the ideal water for domestic uses. Several of the outstanding papers presented before the main sessions of the association were presented by members of the Water Purification Division. A review of some of the more important papers follows:

Committee on Standard Methods of Water Analysis.—Jack J. Hinman, Jr., Chairman, presented a lengthy report on the activities of the committee since its last meeting in June, 1929. Discussion centered largely around the inability of the committee to get favorable action by the Committee on Standard Methods of the American Public Health Association on several of its recommendations. Dr. Norton, secretary of this committee, stated one reason was that the Committee on Standard Methods of the A. W. W. A. had failed to submit specific recommendations.

Revision of Water Works Manual.—The group headed by Paul Hansen, Chicago, on revision of the chapters of the manual relating to the quality and treatment of water held a meeting June 2 and decided to recommend that a series of monographs be published at the present time instead of a revised manual. The monographs are to cover quite fully current practice in the treatment of water. At a later date the monographs may be condensed into a few chapters of a manual. A number of those present thought that the manual should be published in two volumes —one relating to sources of the water, treatment and quality; and the other to pumping stations, distribution systems, finances, etc.

The Development of Railway Water Supply Practice.—C. R. Knowles, Chicago. Presented before the Main Session. The author of this paper gave an interesting outline of the part played by the American Railway Engineering Association and the Boiler Feed Water Studies Committee in developing the treatment of railway water supplies. About one-third of the water used by the railroads in the United States is bought from the public supplies along the lines. The railroads have to use water from many sources, which makes the problem more difficult than if it was of uniform quality. Improving the quality of the water has materially increased the engine mileage on a number of railroads. J. B. Wesley, St. Louis, said the Missouri Pacific Railroad runs through nine states and uses water varying widely in characteristics. It has 89 treatment plants. C. H. Koyl, Chicago, discussed the mechanism of boiler corrosion and how it could be controlled. Now it is known that the purest iron will dissolve in the purest water. Prevent the escape of hydrogen and corrosion is prevented. Open feed water heaters that remove the dissolved oxygen so that the hydrogen will not be oxidized, and a solution sufficiently alkaline to prevent escape of hydrogen gas, prevent corrosion.

Recent Progress in the Art of Water Treatment.—Abel Wolman, Baltimore, Wellington Donaldson, New York, and Linn H. Enslow, New York. Presented before the Main Session. This paper gave an excellent resume of progress in the art of water treatment. There have been no recent changes in the basic process of water purification. An artificially constructed slow sand filter unit was put in operation in Chelsea, England, in 1829, and description of a rapid sand filter with coagulant appeared in 1885. Chlorine was used for the disinfection of water in Belgium in 1902 and in this country in 1908.

"As time progressed, the citizen demanded safety in addition to clarity. Today, these demands have been multiplied manifold so that the water works operator must supply water that is clean, that is hygienically safe, that is tasteless and odorless, that will not destroy the distribution pipes in which it flows, that will make the life of the housewife less difficult in laundry and domestic uses, and that will supply the increasingly important demands of the industrial consumer. The motto of the twentieth century is 'more and better water.'" Preammoniation, permanganization, superchlorination and activated carbon have been found effective in the prevention or control of tastes and odors. In addition to reviewing the methods for taste and odor elimination, the authors reviewed recent developments in coagulation, chlorination, correction of corrosion, water softening, iron and manganese removal, and analytical methods and laboratory control. They made available to the water works practitioner unfamiliar with technical details of

water treatment, the important advances in recent years. W. W. Brush, in discussing the paper, stated that the reason for such exacting demands from the public was that the water purification operators themselves had created the demand by supplying water of such a high quality.

The Purification of Highly Turbid Waters.—John D. Fleming, St. Louis. Presented before the Main Session. An outline of the treatment of the muddy Missouri River water at the Howard Bend Station of the St. Louis Water Division was given. The plant includes preliminary sedimentation in basins equipped with Dorr clarifiers, treatment with lime and iron, mixing in circular tanks, settling first in basins equipped with Dorr clarifiers, secondary sedimentation in plain settling basins, recarbonation, coagulation with aluminum sulfate, filtration, and chlorination. Without continuous sludge removal the basins handling the coagulated water would fill completely within about 50 days. Part of the sludge removed is returned to the presedimentation basins, materially increasing their efficiency. Flue gases from the boiler plant are used to carbonate the water. No trouble has been experienced by the use of such gases. Pipes for the removal of sludge from settling basins must have a fairly high velocity to prevent clogging.

Recent Water Borne Disease Outbreaks and Their Significance.—Abel Wolman, Baltimore, and A. E. Gorman, Newark. Presented before the Main Session. Typhoid epidemics within the past 10 years resulting from the transportation of the infectious germ by water indicate that there has been a decline in interest in and attention to safeguarding details of the problem by health officers and water works operators. If there has been a change in the typhoid epidemics, it has been in the direction of increased severity. Due to the decreased artificial and natural immunity of populations, a typhoid epidemic, when it does strike, hits heavily. The optimistic idea that typhoid is under control is erroneous. Montreal, Canada, and Hanover, Germany, have been visited in the last 10 years by the greatest recorded single typhoid epidemics in history. In Montreal, where the bacillus was milk-borne, there were approximately 5,000 typhoid cases, resulting in 260 deaths, and in Hanover, where the germ was transported in water, there were about 4,500 cases, with 380 deaths. That typhoid epidemics are not a thing of the past is demonstrated by the fact that 226 epidemics occurred within the past 10 years. Sixty-seven of these resulted from water supplies of surface origin that were untreated, 54 from underground water, 43 from failure of modern water purification devices, and 31 from mishaps after the water had left the treatment plant. Detroit had an outbreak of dysentery in 1927, due to a sudden pollution of the raw water before filtration and failure of the treatment plant to properly treat the water for a short period. The Health Department of Detroit estimated that 45,000 to 50,000 cases resulted. The trend of judicial opinion on the epidemic question is towards penalizing water works operators in dollars and cents for damages resulting from the ravages of the disease.

Private Cross Connections and Similar Menaces to Quality of the General Public Supply.—Joel I. Connelly, Chicago. Presented before the Main Session. The author called attention to the number of ways in which the water supply may be contaminated from cross connections and connections of the pipes to tanks that may become contaminated. The connections to sinks, flush toilets, etc., are frequently of such a nature that water may be sucked back into the pipes when the pressure is cut off. He advised that all connections of the water pipes be made so that water cannot get back into the system when such conditions happen. S. B. Morris said that Pasadena, Calif., had recently passed an ordinance which prohibits dangerous cross connections in plumbing work.

The papers abstracted below were presented before the Water Purification Division in three well attended sessions, in a room filled to overflowing practically all the time and so hot that coats had to be discarded. Nothing but an unusually interesting program would have attracted so large a number of listeners under such unfavorable conditions. It is hoped that the comforts of this division will be given more consideration at future conventions.

Successful Application of Superchlorination and Dechlorination for Medicinal Taste to a Well Supply, Jamaica, N. Y.—Frank E. Hale, New York. An unusual case of medicinal taste was thought to be due to oil and gasoline wastes from a garage which penetrated through the ground to the wells. The addition of a very small amount of gasoline to water and then treating with chlorine in quantities generally used for sterilization of the water produced the medicinal taste characteristic of chlorophenol. This taste could be largely eliminated by superchlorination. Superchlorinating the well supply and dechlorinating with sulfur dioxide only a short time afterwards produced satisfactory results.

Progress in Superchlorination Treatment for Taste Prevention at Toronto.—Norman J. Howard, Toronto. Superchlorination followed by dechlorination treatment of the city water for the prevention of taste was first successfully used at Toronto in 1926. At first the equipment was inadequate, but at the present time that are 10 chlorine machines and 8 sulfonators in commission. These machines have a combined capacity of 5,400 lb. daily. At first there was difficulty in maintaining adequate sulfur dioxide cylinder pressure. The sulfur dioxide is now drawn off as a liquid and discharged into 150-lb. steel cylinders immersed in a water bath. By maintaining a water temperature of 190° F., an operating pressure of 45 to 58 lb. is maintained. The sulfur dioxide is shipped in 1-ton cylinders. The opinion was expressed that ammonia present in the raw water offers little or no protection against taste conditions, but if the water is treated with quantities of applied ammonia, the taste condition can be corrected. In at least three known instances the superchlorination and sulfur dioxide treatment has proved ineffective in preventing taste. Activated carbon may be effective in removing tastes not eliminated by the superchlorination treatment. The cost of the super- and dechlorination treatment is $0.72 per million imperial gallons. Louis B. Harrison, in discussing the paper, stated that the superchlorination treatment was not successful at Bay City, Mich.

Chemical and Mechanical Utilization of Activated Carbon in Water Purification.—A. S. Behrman and H. B. Crane, Chicago. The successful use of activated carbon has been demonstrated by installations in industrial plants. In the municipal field its use to date has been confined largely to experimental units. Experiments and full scale experience have demonstrated that the proper sort of carbon may be used successfully for the removal of practically every kind of organic taste and odor, for the elimination of free chlorine, for the removal of organic coloring matter, and for the separation and removal of iron. The advantages of the carbon treatment is the purification accomplished and the ease of operation. When combined with the superchlorination treatment it automatically and accurately dechlorinates without attention from the operator. There is no accurate information as to the life of the carbon and its cost, for none has been in use long enough for the life to be determined. Not all carbons possess the proper kind of activity. An excellent gas adsorption carbon may not be a good decolorizing carbon. The decolorizing carbons appear to be the best suited for water purification. Hydrodarco is made from Texas lignite. It contains about 70 per cent carbon and weighs about 18 lb. per cubic ft. Plant layouts for the use of carbon units were illustrated. The authors also described and illustrated how existing plants could be equipped with carbon units. Paul Hansen, Chicago, stated that engineers must give consideration to the possible use of carbon in the design of future filtration plants.

The Use of Activated Carbon for the

Removal of Taste and Odor from Water.—George D. Norcom. The author gave the results of experiments with activated carbon on highly polluted water which contains objectionable tastes practically all the time. The municipal supply at Chester, Pa., is polluted by a variety of industrial wastes and sewage. Superchlorination did not prove successful in removing the tastes. A series of experiments of fairly long duration on the effectiveness of activated carbon in removing objectionable tastes were illustrated. One brand of carbon (hydrodarco) removed all tastes from the water during the several months' duration of the test. Passing stream through the carbon beds partially revivified the carbon. Robert Spurr Weston, Boston, in discussing the paper, spoke encouragingly of the use of activated carbon.

Further Observations on the Use of Activated Carbon in Removing Objectionable Tastes and Odors from Water.—John R. Baylis. This paper brings up to date the experiments on activated carbon which have been under way for two years at the Chicago Experimental Filtration Plant. A former paper published in the June, 1929, issue of the "Journal of the American Water Works Association" gave the results of the experiments up to that date. Rates of passing the water through the carbon units, depths of beds, and methods for revivification were discussed in the latter paper. Several brands of carbon show good dechlorinating properties. Of the materials tested, Hydrodarco gave the best results. It gives promise of being a very cheap means of dechlorinating water, as well as being effective in removing taste producing compounds not eliminated by superchlorination. The experiments are still under way. Charles P. Hoover, Columbus, discussed the patent situation in reference to the use of activated carbon in water treatment. W. A. Helbig, New York, stated there was evidence of a concentration of both free chlorine and organic matter on the surface of the carbon, which probably aided in the oxidation of the organic compounds. E. B. Showell, Jr., Buffalo, gave an account of the use of bone char containing about 10 per cent of carbon in removing tastes and odors from the water for drinking purposes at the Du Pont Rayon Company's plant at Buffalo. The water is highly polluted with sewage, and is prechlorinated to prevent septic action in the settling basins. The water has a residual chlorine of 0.15 to 0.35 ppm. after filtration. When tastes were noted in the water going to the carbon units, it was completely removed 54 per cent of the time, 24 per cent of the time it was slight, and the balance of the time it was bad. He did not regard passing the water through beds of bone char which had been in service several years a satisfactory solution of their taste problem, even though it dechlorinated the water.

Some Neglected Dangers to Water Quality.—Jack J. Hinman, Jr. Prof. Hinman gave an excellent discussion of some of the things frequently neglected in the protection of water against contamination. Cross connections to polluted supplies or connections to fixtures where the water can be sucked back into the pipes when the pressure is low or is off, are always a danger to the quality of the water. He related how specimen jars in a laboratory on the upper floor of a building, which had tubes leading below the water level in the jars, had contaminated the water in the building when the pressure was cut off for a short time.

Unusual Color Removal Plant for Part of the Los Angeles Water Supply.—Carl Wilson, Los Angeles. This paper, which was read by Chairman Hale, described experiments on water of an unusual nature. The water contained color as high as 125 ppm. and could be successfully coagulated only with ferric chloride. The procedure that gave the best results called for several modifications of existing filtration practice. It was found necessary to use sand of 0.9 mm. effective size and to use beds only about 10 in. thick. Returning the sludge gave added color removal. The precipitated ferric hydroxide from a given amount of water, when removed and added to an equal amount of the raw water, gave considerable decolorization. It could be used several times before it lost its power to remove some of the color. Seth G. Hess, New York, and L. L. Hedgespeth, Philadelphia, gave interesting accounts of the use of ferric chloride for treating water.

The Trial Filtration Plant, Ottawa, Canada.—George G. Nasmith, Toronto. The author gave a description of the Ottawa Experimental Filtration Plant. The plant was constructed to demonstrate that the colored Ottawa River water could be handled successfully. Chlorinated iron did not give satisfactory results. Aluminum sulfate gave good results, but it must have a fairly long period of mixing to get good settlement of the coagulated matter. The coagulated matter does not form a mat at the surface of the sand, but penetrates into the sand bed. Coagulated matter frequently passed through the sand beds before the loss of head reached the maximum. W. E. MacDonald, Ottawa, stated that good mixing was obtained by eliminating the stirrers and giving the water a spiral flow through the mixing tanks.

Prechlorination in Relation to Filter Plant Efficiency.—H. W. Streeter, Cincinnati. By prechlorination, raw water containing as many as 20,000 B. Coli per cc. could be filtered and meet the Treasury Department standard without producing objectionable chlorine tastes. This is about twice what may be handled when the water is chlorinated after filtration only.

Observations on Filter Sand Shrinkage.—W. M. Wallace, Robert Hulbert and Douglas Feben, Detroit. Increasing the rate of wash on the filter beds at the Detroit Filtration Plant materially improved the condition of the filters. The sand was first cleaned by treating with sodium hydroxide and then thoroughly washed with a hose. The rate of wash was increased as much as the washing system would allow. This gave a sand expansion slightly less than 50 per cent, the 50 per cent expansion being found to be about the ideal wash in the experimental work. The high rate of wash has prevented the sand grains from becoming heavily incrusted as they did formerly. A new theory of sand shrinkage was given. The sand grains settle loosely after washing, and when the pressure increases due to the increase in the loss of head the grains are forced together in a more compact form, causing the bed to shrink. It was shown that practically all increase in the loss of head over the initial loss took place in the top 3 or 4 in. of sand. The loss of head along the sidewalls below the sand surface, where there is shrinkage of the bed, is very little, whereas a clean bed will show a sidewall loss nearly equal to that of the center of the bed. The reason why there is very little loss where there is shrinkage is due to the sand being pushed away from the sidewall. The formation of clogged areas along the sidewalls of the filters was explained. When a clogged area starts forming the wash water is deflected from its regular course. The authors suggest that the application of more wash water near the sidewalls might be of advantage. The paper was discussed by Frank W. Herring, Chicago, and Charles R. Cox, Albany, N. Y.

Manipulation of pH at Springfield, Ill., Water Purification Plant.—Charles H. Spaulding, Springfield. Lime is applied to the water in excess, then it is recarbonated to make it chemically stable. Stack gases are used as a source of CO_2, and there has been no difficulties encountered by the use of such gases. Analyses made on the water before and after passing a hot water system showed that magnesium and silica were deposited in greater quantities than calcium.

Efficient Water Works Operation and the Purification Laboratory.—Martin E. Flentje, Harrisburg, and P. S. Wilson, New York. The authors gave interesting illustrations of how the laboratory was used as an aid to efficient and economical operation of water works systems. The operators with little or no technical training are taught how to make certain tests that are essential for the operation of the purification plants. They are equipped with stirring machines and daily tests

are made to determine the minimum quantity of coagulant that may be used. Control of corrosion produces considerable operating saving in the systems that are corrosive.

Elimination of Taste in the Water Supply of Lancaster, Pa.—Edward D. Ruth. Experiences with the use of ammonia with chlorination was described. The ammonia is fed into the water in advance of the coagulant and the chlorine after filtration. The treatment has successfully eliminated all tastes produced by chlorine. No objectionable tastes of any kind have been noted since the treatment was started. In reply to those discussing the ammonia treatment, the author stated that he has heard many favorable comments on the quality of the water since the treatment was started.

Preammoniation of the Filtered Water Supply of Cleveland, O.—J. W. Ellms. A description was given of the large plant installations of ammonia equipment for adding ammonia to the Cleveland water. Chlorophenol and other tastes due to the addition of chlorine are entirely eliminated. The chlorine is applied shortly after the ammonia. An average of 0.12 ppm. of ammonia has been used. The cost is about 30 ct. per million gallons.

The two papers on ammonia treatment attracted considerable attention. There were several written and a number of oral discussions. Howard J. Pardee, Long Island City, stated that much more work was needed to be done on the use of ammonia. Louis B. Harrison said it did not remove the objectionable tastes at Bay City, Mich. W. C. Lawrence defended its use at Cleveland and stated that it had vastly improved the quality of the water.

Efficiency of Chlorination at Chicago.—H. H. Gerstein, Chicago. Fifty thousand analyses covering a period of 5 years were used in making the study. The B. Coli in the chlorinated water increased as the B. Coli in the raw water increased. When the raw water averaged 100 B. Coli per 100 cc. the chlorinated water averaged 0.074 B. Coli per 100 cc., and when it averaged 1000 B. Coli the chlorinated water averaged 0.187. The chlorinated water averaged well under the Treasury Department standard all the time. This is due largely to the very efficient chlorine control in seeing that the water has a residual all the time. The efficiency of the chlorination dropped off as the turbidity increased. There were several discussions of the paper.

The Elimination of Coli-Aerogenes Contamination, Due to Pump Packing, from a High Pressure Centrifugal Pump.—Arthur F. Mellen, Minneapolis. An interesting case of how water may show a decided increase in B. Coli from the packing of a high pressure pump was given. B. Coli grew on the packing, and when the pump was thrown into service the water-seal pressure forced water from around the packing into the suction side of the pump. The author explained how a change in the water-seal could be made to prevent contamination. In discussing the paper, Fred O. Tonney stated that if a slight change could be made in the pump design, as indicated, this probably was the best way to overcome such troubles.

A Demonstration of Direct Counting of Coli-Aerogenes Organisms in Cyanide Citrate Agar.—Ralph E. Noble and Fred O. Tonney, Chicago. The need for a method of direct counting of organisms of the coli-aerogenes group was discussed. Plates containing the colonies of B. Coli and the aerogenes were demonstrated. Such a procedure gives a direct count of the organisms, which is desirable. It also enables the determination to be made in a much shorter time than the procedure now generally used.

American Water Works Association Membership Campaign

The A. W. W. A. Membership Drive for 500 new members in 1930 has reached the 440 mark, or 88 per cent of the quota on June 15. Several of the state sections have over-subscribed their quota, with Wisconsin leading, Central States second and New York third.

The Central States led the list at the opening of the St. Louis convention, but was passed by the Wisconsin Section, due to a number of applications brought to St. Louis by W. C. Muegge of the Wisconsin Membership Committee.

Bill Lawrence of Cleveland, who captained the Central States Membership Committee, is going out to win back first place in this campaign and it looks as if before the end of 1930, with this kind of spirit prevailing in the leading sections, the hope of Chairman A. E. Gorman to bring in 500 new members over and above normal expectancy, will be realized.

One of the surprises of this campaign is the new foreign members which have been received during the last two months, totaling 23.

Plans are now being perfected in the various state committees, to organize special membership campaigns this fall in connection with the annual meetings of the various sections.

Results of 1930 Membership Campaign, American Water Works Association, as of June 15, 1930

Section	New Members	Restored Members	Total Membership	Quota	Per Cent of Quota
GROUP NO. 1—255					
Organized Sections—					
Wisconsin	17	1	18	10	180
Central States	60	2	62	40	155
New York	74	4	78	55	142
Southeastern	34	1	35	30	117
Pacific Northwest	15	1	16	15	107
Kentucky-Tennessee	20	1	21	20	105
California	23	2	25	25	100
GROUP NO. 2—75					
Missouri Valley	25	3	28	30	93.5
Florida	9	3	12	15	80.0
Illinois	18	2	20	25	80.0
Indiana	14	1	15	20	75.0
GROUP NO. 3—75					
North Carolina	6	5	11	20	55.0
Montana	3	0	3	6	50.0
Four States	26	1	27	55	49.2
New England	11	0	11	15	44.0
Canadian	11	2	13	30	43.4
Rocky Mountain	8	0	8	20	40.0
Minnesota	2	0	2	12	16.7
GROUP NO. 4—35					
Unorganized States—					
Foreign	23	0	23	5	460.0
Nevada	1	0	1	2	50.0
Southwest (Texas, Oklahoma, Arkansas)	6	2	8	25	32.0
Virginia	3	0	3	10	30.0
Louisiana	0	0	0	5	0.0
	409	31	440	500	88.0

The National Hydraulic Laboratory

The fixed equipment for the national hydraulic laboratory to be established in the Bureau of Standards at Washington will include electrically-driven pumps for circulating the water, a large concrete water-supply basin, a concrete measuring tank, several steel weighing tanks, elevated control tanks for supplying water under several different systems for distributing this water to all parts of the laboratory and for returning it from the models under test to the supply basin. A large unobstructed floor will be provided where a number of models can be built and tested simultaneously.

Owing to the great variety of problems which will be submitted for study, the equipment of the new laboratory will be designed to furnish the greatest possible flexibility of arrangement and combination, so that it can be adopted easily to the simultaneous study of a number of different problems.

The bill authorizing the establishment was signed on May 14 by President Hoover. It provides an appropriation of $350,000.

Efficiency in Meter Reading

How This Important Matter Is Handled by One of the Largest Water Companies in This Country

By L. D. SHIVELY

Chief Meter Reader, Indianapolis Water Co., Indianapolis, Ind.

Efficient meter reading is one of the most important matters confronting a water company. In the successful operation of a company there must be efficient management, efficient engineering and efficient office operation. It is equally important that there be efficient meter reading. The difference between an efficient meter reader and an inefficient one is that one thinks about his work while the other does not. The difference between an efficient and an inefficient meter reading department is measured in thousands of dollars of revenue. How the Indianapolis Water Company secures efficiency in its meter reading is told herewith, the matter being abstracted from a paper presented by L. D. Shively before the Indiana Section of the American Water Works Association.

IN the building of an efficient meter reading department, there are many things to be considered, the first being the type of men best fitted for this work. They must possess tact, and be able to think clearly and accurately. They must be courteous, have a pleasant disposition, and keep smiling through the most trying circumstances. Although they have to help move kitchen cabinets, tables, beds, rugs, etc., from trap doors before they can enter the basement to read the meter, they must still say "Thank you" when they are through. No employe of the company meets more people than does the meter reader. In fact, he is the only employee of the company some customers ever see. When they get their bill they mail a check, and if they have a complaint they write a letter. They seldom, if ever, contact with the office. It is, therefore, highly important that the reader create the most favorable impression possible on the people with whom he comes in contact. In the minds of the majority of the customers he is the water company. He is its one and only representative.

Location of Meter.—The next matter of importance is the location of the meter. If we expect the meter readers to give the best service, we should be very particular where we set the meter. The meter must be read at frequent intervals, therefore it should not be placed behind a furnace, in a coal bin, or in a cellar that is little more than a hole in the ground. If in a meter box, we should be sure the lid of that box is slightly above ground level. We should not expect a man to keep smiling, or be efficient, if he has to crawl behind furnaces, climb over coal and ashes, or remove two or three inches of dirt from pit lids.

Routing of Readers.—Another matter of vital importance is the routing of the meters. This must be done so that a reader will not be compelled to take unnecessary steps. Our company is now completing a routing system, and our experience indicates that it measures close to 100 per cent efficient. The city was divided, as nearly as possible, into sections five squares each way. Each section was numbered in such a way that if any changes are made, such as cutting new streets, the section can be renumbered without affecting any other part of the routing system. Instead of the reader zig-ragging back and forth across the street, weaving in and out among fast traveling automobiles, etc., he goes up one side of the main street and back the other, reading the cross streets for one square by the herring-bone system.

A blue print was made of each section; the streets marked off in 20-ft. spaces, and two numbers allotted to each space. Inspectors took the blue prints out on the territory and placed the property numbers on these prints in their exact location. Although the house numbers may be changed the meter account numbers remain the same. We have been more than four years perfecting and completing this system, but our experience proves that the time was well spent. The increased efficiency of our meter readers far outweighs the expense of instituting the new routing system.

Readings Per Day.—The next question of importance is how many readings should a reader procure in a day. This would be easy to answer if all we expected of a reader was to get a reading of the meter.

A year or so ago F. C. Jordan called me into his office and asked me to read an article written by a superintendent of a southern water company, in which the superintendent praised his meter readers, and said they were undoubtedly the best in the country. According to his report the readers averaged 274 readings per day. Our quota is 180. Was the mere fact that their readers procured 274 readings per day an indication that they were efficient? Our experience indicates that a reader cannot read 274 meters per day and be efficient in all matters properly coming under his charge. He is probably just a "statement taker." There are other points to be considered that we feel are just as important as getting a reading of the meter. The trend of our thought today is that these men are water company representatives and not merely meter readers, and our system is being remodeled along that line. At the present time these representatives have six other duties, namely: (1) Packing the stuffing boxes of the meters. (2) Making investigations to determine the cause of high consumption. (3) Testing the meters to make sure they are registering all the water that passes through them. (4) Locating consumers who vacate houses supplied with water by us, without notifying us. (5) Making inspections where houses are occupied and meter sheets shows water off. (6) Making take-out and test tickets where the meter has registered a certain quantity as designated in our Standard Practice.

Packing Stuffing Boxes.—The first item, "packing stuffing boxes," is of importance to the water company, because any leak at this point is the company's loss. Also, if a leak at this point continues, the small hole in the hood where the water is supposed to escape becomes clogged, the water cannot get out and corrosion sets in in the clock gears and destroys them in a very short time. We believe that the meter reader should pack the stuffing boxes when they are leaking, as it only takes him from three to five minutes. If this work is done by the distribution department, the service man must make a special trip, making the packing of the meter more expensive, and causing an added annoyance to the consumer.

Leak Inspections.—The second item, "Making leak inspections," is of importance to the customer, and is also important to the company when viewed from the standpoint of public relations. It is our policy, although we do not consider it our duty, to help a consumer find the cause of any high consumption. This service is sometimes not properly appreciated, but we know it is appreciated by some because many have written or called at the office and expressed their thanks.

During the month of December, 1929, our meter reading department made 552 leak inspections, and the monthly average for the year was about 400. If this valuable service is to be rendered the meter reader is the logical man to perform it.

Meter Testing.—The third item, "testing meters to make sure they are registering all the water that passes through them," is the most important of all to the water company, and applies especially to the commercial and industrial meters. It is necessary that a meter reader be able to read a meter correctly, and know that the meter is registering all of the water that passes through it. Some meter readers are expert "statement takers," but unless they familiarize themselves with the different types of consumers, and learn to know how much water they should use, they cannot be classed as efficient.

The fourth item, "locating consumers who vacate houses supplied by us without notifying us," is also of great importance to the water company, and a meter reader can render invaluable service to the collection department by procuring this information.

The fifth item, "making inspections where houses are occupied and reader's sheets shows water off," is important as there is hardly a month that the readers do not find one or more properties where the water is on without the company's knowledge. A reader should also watch houses that have no city water. Sometimes a plumber installs fixtures in a house, turns the water on, but does not immediately notify the office.

Take-Out and Test Tickets.—The sixth item, "making take-out and test tickets where meter has registered a certain amount," is one that must be taken care of by the meter reader. Instead of ordering a meter out for test after it has been in service a certain number of years, we now order it out after it has registered a certain quantity of water. This does not mean that all meters will be left in until they have registered a specified amount. If at any time a reader feels that a meter is slowing down, and not registering accurately, it is his duty to order it out for testing.

Missed Meters.—The question of "missed meters" is becoming a more serious problem every day. Should we let the readers use pass keys to gain admittance to homes? We do not believe they should unless we are granted permission by the consumer. If the readers, as they go around the side of the house, will call out "Water man," loud enough to be heard in the house, but not in the next square, it will save them time in gaining admittance, and lessen the number of "missed meters." The occupant knows who is coming, and will not hesitate to let him in. On the other hand, if the reader does not call but just knocks on the door, the occupant frequently does not answer, thinking it is some agent or peddler.

We have meters in a number of homes, where both husband and wife work, and there is no one at home during the day. We have been furnished keys to many of these, so that we may have access. These keys are kept in a locked room except when the readers are using them.

Another matter that may seem rather insignificant to some readers, but is really very important, is the marking of meter locations on the readers' sheets. Especially is this true where the meter is back of a furnace, or in some unusual location. If this is done it will speed up the work of the reader, and make it much easier.

Uniformed Readers.—Two years ago our company adopted the policy of uniforming the meter readers. Frequently we are asked why we did this. There are three main reasons. In the first place it makes it easier for them to gain admittance to homes. Second, it gives the readers a neater appearance, provided he takes the proper care of his uniform. Third, it is a protection to both the company and the customer. In this day of "fake meter readers," "telephone inspectors," etc., it is important that we protect our customers as far as possible, and the uniforms serve this purpose. The cost of the uniforms, which is about 1/7 of 1 per cent per meter reading, is far overbalanced by the increased efficiency of our readers.

Credit System for Readers.—We have outlined the duties of a meter reader in addition to the reading of the meter. He should be given proper credit for this additional work. We should not expect the man who packs 10 or 12 meters, and makes a like number of inspections, to read as many meters in a day as the man who does not pack any meters or make any inspections.

A logical plan is to use a point system. Instead of so many readings per day, we should require a man to make so many points. Allow one point for each correct meter reading, one-half point for each missed meter, two points for packing a meter, two points for making a leak inspection, and one point for locating a consumer who has moved without notifying us.

When a man is employed as a meter reader by the Indianapolis Water Co., he is first taught how to read meters, and then is sent to our meter repair department for two or three weeks' training. Here he learns the construction and operation of all types and sizes of meters. We find this schooling invaluable. Also, in order to develop the meter readers to the degree of efficiency they should attain, and make them real representatives of the company, the Indianapolis Water Co. has adopted the policy of holding regular meetings of the commercial department employees, including bookkeepers, billers, contract window men, telephone operators and meter readers. At these meetings the readers are brought face to face with the problems confronting the office employees. They learn how much trouble may be caused by their mistakes of omission or commission.

We must constantly impress upon their minds that their position is one of the most important in the water company organization. They should not be just ordinary meter readers, capable only of transferring a reading from a meter dial to a reader's sheet, but they should be intelligent representatives of the water company in the homes, and business places that they visit.

Dramatize Scientific Progress

The work of engineers and scientists, generally considered prosaic and matter-of-fact, was heralded in pageantry at Hoboken, N. J., by George Pierce Baker, widely-known dramatist of the Yale University Theater, before prominent engineers from more than 16 countries attending the Fiftieth Anniversary Celebration of the American Society of Mechanical Engineers.

In what is probably the first dramatic review of the history of engineering, Dr. Baker graphically depicted crises in the careers of the men whose inventions and discoveries have resulted in the present machine age.

The young and poor George Stephenson, pleading before an august parliamentary committee for permission to build a railroad between Liverpool and Manchester, was portrayed. Amid arguments that the noise would frighten the farmers' cattle and through cries of "Fool!" and "Idiot!" the undaunted inventor predicted the day when "it will be cheaper for a workingman to travel upon a railway than to walk on foot."

Michael Faraday, finder of many laws of electricity, gave the true reason for pure research when he replied to the woman who, watching a magnetic needle revolve around a wire carrying a current of electricity, asked: "Of what use is it?"

"Madam, what is the use of a newborn child?" he countered.

Faraday was shown in the pageant refusing his friends' alluring offers of money so that he could stay in his laboratory and learn more about electricity.

A business bargain is the crisis in the life of James Watt. The pageant showed Watt in complete despair, his funds for experimenting exhausted, forming his famous partnership with Boulton, out of which came the first commercially successful steam engine.

The visit of the New York aldermen to Edison's laboratory to see if the new electric lights would be suitable for street illumination was chosen by Dr. Baker from the dramatic career of the aged inventor. The pageant also showed Alexander Graham Bell speaking the first words ever sent by telephone when he excitedly called his assistant from a distant room, "Mr. Watson, come here! I want you."

Incidents from the lives of Morse, the inventor of the telegraph, and Fulton, of steamboat fame, were also dramatized.

Installing 20 in. Mains by Jacking Method

How Two Protected Lines Were Placed Under Double Track Railroad Without Traffic Interference

NOT a moment's delay to traffic and a greatly increased saving in time and money were features of the recent installation at Marion, Ind., of two water mains under a busy double track railroad by the jacking method.

The city of Marion has recently completed a number of betterments to its municipal water-works which will improve the quality of the water and increase the capacity of its plant. The demand for a greater supply of water made necessary the construction of a large storage tank, 150 ft. in diameter. The only available space for a tank of this size was on the opposite side of a railroad which skirts the plant grounds on the south. Placing the new tank in this location created the problem of installing the two 20-in. water mains which were necessary to connect the new tank with the original 80-ft. tank on the north side of the tracks. The plans called for the one main to be placed at a depth of 21 ft. below track level and the other to be placed directly over this on a 7.8 per cent grade, with the upper end 10 ft. below track level.

The railroad under which these water mains were to be placed is a double track line connecting Chicago, Ill., with Columbus, O., and consequently is a very busy road. Therefore, the railroad officials were particularly desirous that the method of installation would not necessitate the issuing of slow orders or cause any other interference with its train schedules.

The construction company awarded the contract for doing the work proposed at first to effect the installation by means of tunneling and suggested this method to the railroad authorities. However, one of the engineers consulted had had experience with the Armco jacking method of placing culverts under traffic and suggested its use instead of tunneling as being more advantageous for both the railroad and the contractor. In this manner, the railroad would be spared any traffic interference and extra maintenance work due to a settling roadbed. Advantages of this method which appealed to the contractor were quicker construction and greater economy than the proposed tunneling method. For these reasons the jacking method was chosen to create the opening in which to place the mains.

An agreement was made with a nearby company fabricating pure iron corrugated pipe, to install the conduits by this method and according to directions given by the contractor. This called for two lines of 42-in. corrugated iron pipe placed at the required line and grade and of a length meeting the safety requirements of the railroad.

Working Trench Showing the General Arrangement of Jacking Setup, also Cover Over Excavated Material

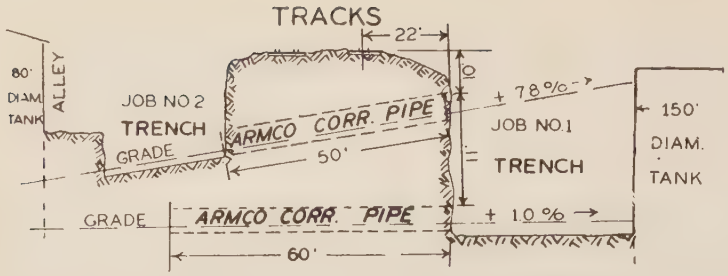
Installation.—A working trench for installing the lower conduit was prepared on the south side of the railroad. The excavated material was heaped up on both sides of the trench, and thus placed, it constituted a menace should rainy weather set in. Rather than remove this material which was later to be used for backfilling, it was considered to be more economical to provide a cover. This was done with salvaged lumber and sheeting covered with roofing paper. As a further protection a roof of the same material was placed on upright posts immediately over the working trench. The wisdom of these precautions was demonstrated during a heavy rain which fell while the job was in progress.

In the working trench thus prepared, the regular jacking setup was made and jacking started. The material encountered was a hard blue clay, slightly plastic in spots, which was excavated by means of air spades and a trench pick. As this material was excavated, it was removed on a small wagon which was drawn to the surface on skids placed at the rear end of the trench. A small hand operated winch was used to furnish the necessary power for this operation. As the excavation progressed, the pipe was advanced by pressure from the jacks.

When one of the 12-ft. sections of pipe had been jacked into the fill for a sufficient distance, the next section was lowered to the lining timbers by means of the skids which also served as a track for the wagon. This was connected to the section already jacked by a field riveted joint and jacking resumed. This process was repeated until the required 60 ft. of pipe was in place.

An approach trench for installing the upper conduit which was to be placed directly over the first was prepared on the north side of the track. The same setup used on the first job was made and operations were begun. The material first encountered was a hard yellow clay which was changed to newer and less stable filled ground as the job neared completion. This excavated material was removed from the pipe to the rear end of the working trench by the box and wagon. From here the box

All Traffic Over the Site Without Slackening Speed



Cross Section Showing Jacking Installation of 110 ft. 42 in. Corrugated Iron Pipe Conduits, Which Provided the Required Openings

was raised to the surface by a small hand operated derrick.

To rush both jobs to completion two shifts of 5 men, each working 12 hours, were used. With the required openings under the tracks made, the laying of the two water mains was easily accomplished.

Conclusion.—This job as completed reveals other advantages than those of non-interference to traffic, no roadbed maintenance and quicker and more economical construction. Laying the mains in a conduit possessing the strength of corrugated iron pipe, protects the main from the vibration of heavy traffic which passes over it. Even if a break should occur in spite of this precaution, the roadbed proper will be protected from washing and its attendant damage and danger to traffic.

The Burnipe Construction Co. of Columbus, O., had the contract from the city of Marion for the improvement of the water-works. They were represented on the job by their engineers, Earl Hoye, who expressed his complete satisfaction with the results obtained from the jacking method. The W. Q. O'Neall Co., of Crawfordsville, Ind., fabricators of Armco corrugated iron pipe, had complete charge of the jacking operations.

Efficiency of Water Purification Plants on the Great Lakes

THE United States Public Health Service has recently issued a report on the efficiency of municipal water-purification systems located along the Great Lakes, from which approximately 10,000,000 people derive their water supply and into which the sewage and industrial waste of about 5,500,000 population are discharged.* The report is based on a survey of 14 representative municipal water filtration plants situated on the Great Lakes and connecting waterways, including the plants of Detroit and Cleveland. The survey, which was made at the joint request of interested local and state authorities, was an extension of previous surveys of a similar nature made along the Ohio and other rivers of the Middle Western and Eastern states.

Owing to the great importance of the Great Lakes region from standpoints of population, commerce, and industry, the maintenance of safe water supplies along these lakes constitutes one of the major water-purification problems of the country. With the increasing pollution of sources of water supply located in various marginal zones of the lakes, this problem is becoming a more difficult one each year, taxing at present, in some instances, the resources of modern water purification.

The difficulties of obtaining safe purified water supplies from the Great Lakes are magnified considerably by the extreme variability existing in conditions of pollution of the lake waters at the several water intakes, which are located in or close to marginal zones of shore pollution, where water movements are subject to the vagaries of winds and countercurrents. In some instances the pollution of these zones probably is subject to seasonal variation, due to large increases in the sewered population residing along the lakes during the summer vacation season.

A study of the performance of the 14 Great Lakes plants included in the survey revealed some interesting similarities and contrasts in the behavior of these plants, both among themselves and in comparison with purification systems of the Ohio type. Perhaps the most striking similarity observed was the existence, at practically every plant, of a well-defined relationship between the bacterial quality of the raw water, as delivered for treatment, and the corresponding quality of the effluent produced at each successive stage of purification. This same relationship, which is one of fundamental importance, had been noted previously in studies of water purification on the Ohio River and on other rivers.

The most important dissimilarity observed was the marked variability in average bacterial efficiency shown by the several Great Lakes plants among themselves and their disparity in this respect from Ohio River plants of the same general type. Among the Great Lakes plants, divergences in efficiency were indicated as being due in some cases to differences in the average density of raw water pollution and in certain features of plant design and operation. In other instances no reason could be assigned for the inequalities noted.

As regards the comparative bacterial efficiency of the Great Lakes and the Ohio River plants, the former were shown consistently to be slightly less efficient with chlorination included, and decidedly less efficient with chlorination excluded, than the latter group. Detailed analyses of the data failed to disclose the reason for these divergences, which do not appear to be explained, as currently assumed, by the relatively lower turbidity of Great Lakes water. It is suggested that they possibly may be due to differences in the chemical composition of the two waters, notably in the hydrogen-ion concentration.

From a study of the relationships observed between the bacterial qualities of the raw waters and effluents of the Great Lakes plants, and from an analysis of their variations, it was concluded, in so far as the production of final effluents conforming to the revised Treasury Department B. coli standard is concerned, that an average density of B. coli in Great Lakes raw waters, as delivered for purification, approximating an index of 4,500 per 100 cubic centimeters appears to represent an upper limit of permissible pollution, beyond which a majority of the Great Lakes filtration plants, as at present designed and operated, would be clearly overburdened. Mean densities ranging from 1,000 to 4,500 per 100 cubic centimeters represent a doubtful zone, within which some plants might be and others might not be overburdened for a significantly large proportion of the time. With average densities ranging below 1,000 per 100 cubic centimeters, the majority of such plants would not be expected to be overburdened except for a comparatively small proportion of the time.

Among the areas studied, the most highly polluted zone of the Great Lakes from which water is taken for purification was located at the extreme southern end of Lake Michigan, where existing purification systems are clearly overburdened. Other zones of relatively high, though not in all cases excessive, pollution was found to be at the extreme western end of Lake Erie, at the outlet of the Detroit River, and along the southern shore of Lake Erie between Cleveland and Sandusky.

*Studies of the Efficiency of Water Purification Processes. IV. Report on a Collective Survey of the Efficiency of a Selected Group of Municipal Water Purification Plants Located Along the Great Lakes. By H. W. Streeter. Public Health Bulletin No. 193.

Recent Progress in the Art of Water Treatment

A Review of the Outstanding Developments That Have Occurred During the Past 25 Years

By ABEL WOLMAN, WELLINGTON DONALDSON and L. H. ENSLOW

Respectively, Chief Engineer, Maryland Department of Health, and Editor-in-Chief, Journal of American Water Works Association; With Fuller & McClintock, Consulting Engineers, New York, N. Y.; Research Chemist, The Chlorine Institute, New York, N. Y.

ON this occasion, marking as it does an important milestone in the history of the American Water Works Association, it is appropriate to take stock of the developments in the art of water treatment during the past 25 or 30 years. In such stocktaking our aim has been to avoid undue complexity and detail in describing new processes and new principles and to present in as simple terms as possible the practical significance of such advances in the art as have occurred in the past quarter of a century. In accomplishing this task, some omissions no doubt have been made in the review, some failures have occurred to recognize priorities, some undue variation of emphasis on importance of contribution is likely to appear, but their excuse lies only in the desire to simplify scattered information for the most practical use possible. Extensive bibliographies have been intentionally omitted and undue references to responsible authorities have likewise been curtailed in order to save space.

Preliminary Sedimentation.—Water has been settled to remove living and non-living materials for many centuries. Improvements in this art are primarily resident in changes in containers and in the development of mechanical devices for the removal of accumulated materials. The best recent examples are perhaps at the plants at Kansas City, Mo., and the new Howard Bend Works at St. Louis. Adequate settling of solids and rapid removal of their accumulations are important assets on especially turbid waters of the Missouri River type.

Interesting contrasts to these procedures are in use at Louisville, where sediment from preliminary sedimentation basins and from coagulation basins, is returned to the raw water when it is unusually clear. At Winnetka, Ill., ground brick clay is added by a dry feed machine to produce artificial turbidity.

Coagulation.—Aside from the rejuvenation of old coagulants and the development of new ones, the most important advance in this phase of the art of treatment is probably in the better understanding of the mechanism of coagulation, with the resulting economies and higher efficiencies attainable thereby. This conclusion appears to be valid when it is recalled that as early as 1903 William B. Bull used ferrous sulphate and lime coagulants at Quincy, Ill.; that, in 1911, he patented the application of ferric chloride, made from chlorine gas on scrap iron, to coagulation; that almost two decades ago excess alum coagulation and split coagulation were used at Springfield, Mass., and that Hale advanced new hypotheses in 1913 to account for observed results on the coagulation of colored waters with alum.

Many of these empirical observations have been later confirmed when more adequate principles and tools were available for testing them.

Perhaps the earliest emphasis on the underlying mechanism of coagulation, with particular reference to the importance of hydrogen-ion concentration rather than alkalinity and to the significance of an iso-electric point for coagulation, was by Wolman and Hannan not quite ten years ago. These observations were important primarily in stimulating discussion and experimentation in the effort to clarify understanding of the coagulation process. That these efforts on the part of a great many workers were successful is attested by the fact that this particular process in treatment is now more scientifically and economically controlled than a decade ago. Much has been contributed to this understanding by the work of Buswell and Edwards in 1922, by Theriault and Clark in 1922 and by Miller in 1924. To these investigations a number of the later developments in coagulation may be traced.

It is impossible to give a complete list of the modifications in and additions to coagulants which have appeared in less than ten years, beginning perhaps with the suggested application of sodium aluminate by Spencer and its gradually extended usage in the municipal and industrial field, either alone or in conjunction with filter alum. Although not universally applicable, it has found a field of importance where its use has been efficient and economical. At about the same time, Coe described a coagulant prepared from 1 part of soda and 4 parts of alum for use in softening processes. DeLaporte was perhaps the first to make practical use of this mixture. The aluminate is now available as a solid material for dry feed equipment. Powell and Christman in 1925 did much to determine the field of application of sodium aluminate with or without alum, and Hedgepeth not so long after showed its effectiveness in conjunction with ferric iron coagulants.

Following the studies by Mohlman and Palmer in 1926 with chlorinated copperas by oxidation of ferrous sulphate solution with chlorine, in sewage sludge dewatering, Enslow and Hedgepeth in 1927 made their first application to the highly colored water at Elizabeth City, N. C., with unusually successful results. Beneficial results of high order have since been obtained at Chickasaw, Ala., Hertford, N. C., Mamaroneck, N. Y., Warren, R. I., and the Chicago experimental filtration plant. In this connection, it is important to point out, largely because it is in contradiction of text book notations of past years, that the best coagulation of these highly colored waters with ferric compounds is at very low rather than at very high pH values.

This is likewise a desirable time to recall to this group that at the 1906 meeting of the American Water Works Association at Boston, the late Prof. George C. Whipple called attention to the "ferro-chlor" process developed by Dr. Duyk and used successfully as a coagulant at the Middlekerke, Belgium, plant, as early as 1902. Whether it was the excessive cost of this coagulant or for some other reason, the process has been quite completely ignored during the intervening 25 years. It now receives a new lease on life and probably will find its place in the armamentarium of the water plant operator. More recently Wilson at Los Angeles, Calif., has found ferric chloride the most effective coagulant for a colored well water supply at Wilmington, Calif. The work of Hopkins (1929), as to the value of trivalent iron in coagulation practice, should be given mention in this connection.

In summary, therefore, the new processes in coagulation rest upon a foundation of better understanding of the mechanism of coagulation. Some of the new coagulants come into use because their methods of production and consequent cost are lower than a decade ago. Their value is in supplying the water plant operator with a more varied choice of coagulating materials. The trend of their use is in the direction of complexity. All of which simpy means that the better the understanding of this phase of water treatment, the more likely we are to develop processes of coagulation which will be specific for certain waters and which will be regulated with a higher degree of information and scientific understanding than has been the case in previous years.

Chlorination.—Some of you may recall some five or six years ago the

debate among sanitarians and water works operators as to where chlorine should be used and why. That debate has now shifted to the question as to where chlorine should not be used and why not. One of the remarkable developments in the field of water purification in the last ten years has been in the widening application of chlorine and its compounds for innumerable purposes. Revivals of application, increase in understanding of mechanism and empirical applications without understanding, but frequently with good results, are the characteristics of the history of the use of this compound in water treatment. Over 30 years ago Sims Woodhead in England employed chlorine as a temporary expedient during a typhoid fever epidemic at Maidstone, England. Its use in ferro-chlor by Dr. Duyk has already been referred to. Perhaps the first large scale application of this compound to water disinfection was by Sir Alexander Houston in 1904 on the Lincoln plant of London. One of the most important contributions to sanitary science was thus made by Sir Alexander in providing for the City of London, through the expedient of chlorination, a water of hygienic safety for a quarter of a century.

The operations in 1908 at the Chicago stock yards and shortly thereafter at the Boonton, N. J., headworks of the Jersey City water supply, both by George A. Johnson, mark the first large scale introduction of this process in the United States. Of no less importance was the early qualitative use for the detection of free chlorine by orthotolidin by Earl B. Phelps, its subsequent study by Professor Sedgwick and F. W. Jones and its further quantitative extension by Ellms and Houser in 1913. The vast importance of the ortho-tolidin test in the practical control of chlorination, however, was not fully emphasized until the chlorine control phases resident in the development of the residual chlorine determinations in Maryland were clarified by Wolman and Enslow during the period 1917 to 1919.

Real progress in the use of these compounds, however, dates from the initiation in 1910 of the use of liquid chlorine by Major Darnall of the United States Army Medical Corps at Fort Meyer, Va. Two years later, liquid chlorine was applied at the Niagara Falls, N. Y., municipal plant through an Ornstein solution feed equipment, developed in cooperatoin with Mr. Harry Huy. From that time to this its application has been extended throughout the world, its control has been improved, its possibilities have been multiplied, its results have been recognized, and the understanding of its action only little improved.

Practically all of the extended applications of chlorine within the last ten years have resulted from the pressure placed by the public upon the water-works operator to produce a drinking water which would be not only hygienically safe, but fit to drink from the comfort standpoint. Tastes and odors have been the blessing of the water-works field, although many an operator would suggest the reverse at the moment when the consumer is pestering him to the utmost on account of the objectionable tastes and odors in the supply. Although the blessing may have been one in disguise, the results of these demands by the public have been and are advantageous.

Originally the trouble from tastes and odors was blamed upon faulty chlorine dosage control. No doubt much of these difficulties, in the days of constant dosage of chlorine, may have been due to true excess or free chlorine. When a great many of these tastes and odors persisted, however, after careful control was introduced and residual chlorine tests were the standing practice in virtually all the plants in this country, it became necessary to search further for a remedy. The work of Race in 1917 at Ottawa, Canada, with chloramine, produced ammonia water and bleaching powder, marks one of the first efforts to obtain a substitute for liquid chlorine or hypochlorite. Although the process did not find wide appliaction, it still survives at Ottawa as a more ecomonical and efficient procedure than the earlier bleaching powder process. In the same way pre-chlorination, i. e., chlorination of raw water before application to the filter beds, was practiced for purposes of disinfection at Harrisburg, Pa. in 1912, and by Powell at Avalon, Md., in 1916. In this field again, application of this plan was delayed considerably by the general tendency of water-works people to delay the use of new procedures until they have demonstrated their value completely.

Pre-chlorination, however, has resulted in the saving of many thousands of dollars in alum required for adequate coagulation. The experience of Howard at Toronto, Ont., since 1921 and by workers elsewhere testify to this conclusion. The chief results of the procedure appear to be in more adequate algae control in basins and filters, lower bacteriological loadings on the filters, improvement in filter bed condition, reduction in wash water consumption, improvement in coagulation and general over-all factor of safety in plant operation. Practical observations by Weston, Howard, Caird, Mangun, Watkins, Whitener, Cohen and Scheepfle, confirm these general conclusions.

Special mention should be made of the increasing application of chlorine to the control of algae growths, largely the result of studies by Hale in 1921. Practical use of chlorine for this purpose has since been made at Lufkin, Tex., by Chester Cohen, at Kansas City, Kan., by Mangun and more elaborate observations by Hale in 1929 on the New York City water supply. Similar extensions of the use of chlorine have occurred in the industry, particularly in treating condenser water to eliminate so-called "slime" deposits, resulting in longer usage of condenser tubes and greater efficiency of heat transfer. Ice plants find the chemical useful to prevent the algae coating of cooling coils. Although this application is of recent date in this country, chlorination of condenser water has been used for a number of years in England. Similar slime growths in paper mills are now being controlled by the chlorination of water supply in re-circulated "white water."

Pre-Ammoniation. — Sir Alexander Houston, recognizing the superior advantages in some instances of chloramine, first suggested the application of ammonia prior to chlorine, in order to avoid tastes resulting from secondary reactions from chlorine with organic material. Apparently saturation of the organic compounds in water with ammonia, at least in some waters, prevents the creation of tastes and odors upon subsequent application of chlorine. In America this was first demonstrated by McAmis at Greeneville, Tenn., and shortly thereafter by Spaulding at Springfield, Ill. The elaborate investigations by Braideck in 1929 at Cleveland, O., showed the value of the process as one of the most practical and economical measures for taste prevention. A number of months of plant operations since the initial experiments at Cleveland seemed to prove that pre-ammoniation is one of the very helpful deterrents to taste and odor production by chlorination. It is important to point out that the cost of pre-ammoniation is reduced by some saving of chlorine. Whether or not it may be universally employed can only be tested empirically. The ammonia dosage required is generally 0.25 p.p.m. of ammonia or less. In addition to the places already mentioned the process is in use at Lancaster and Erie, Pa.; at Cleveland, Warren, Defiance and East Liverpool, O.; Mamaroneck, N. Y.; at the Hyattsville plant of the Washington Suburban Sanitary District and at Burlington, N. J.

Permanganization.—Again the water-works profession is indebted to Sir Alexander Houston for the development of another process of taste prevention or destruction with permanganate, through his work in 1925 and 1926. As far as we can discover James N. Caird was the first worker in America to use potassium permanganate with success in taste elimination or prevention. In 1929, Harrison at Bay City, Mich., applied permangante to the raw water in sufficient quantities to carry the pink color of the permangante through the mixing chambers. In 1930, Rosenthal made use of the same process in the Dallas, Tex., raw water, also with success. In this instance, too, wider application of this chemical has been delayed either because of the fear of

manganese troubles or the cost of permanganate. Those who have used the process have had considerable success and some prefer it to ammonia treatment. Observation appears to indicate that waters of high dissolved organic content contributed by industrial wastes or decayed vegetation are somewhat more amenable to permanganate treatment than to ammoniation. Waters, on the other hand, containing only small amounts of the end products of decayed vegetation or organic industrial wastes are amenable to preammoniation. In some instances permanganate has aided coagulation, apparently due to the "flocking out" of manganese with alum or iron.

At the present writing permanganate has been used at intervals at about ten plants in America, in quantities varying from 0.04 to 1.0 p.p.m. The plants include Bay City, Mich.; Dallas, Tex.; Rensselaer, N. Y.; Roanoke, Va.; Western New York Water Co. of Lackawanna, N. Y.; Rochester & Lake Ontario Water Co., at Rochester, N. Y.; Newberry, S. C.; Mamaroneck, N. Y.; and East Chicago, Ind.

Super and De-Chlorination.—Both Adams and Houston experimented successfully with super and de-chlorination in 1924 and 1925. Under the guidance of Norman J. Howard, super-chlorination and de-chlorination with sulphur dioxide gas were started in Toronto, Ont., in 1926. Since 1927, it has been used continuously and on a large scale to prevent tastes in the Toronto supply whenever the wind direction blows pollution from the harbor out to the intake in Lake Ontario. The process has attracted international interest and apparently has proven successful, not only at Toronto but elsewhere. Under the supervision of Hale it has recently been used at Jamaica, N. Y., with success.

Activated Carbon Filtration.—Great progress in the study of tastes and odor elimination by filtration through beds of activated carbon has been made in America within the last two years. Many years ago, however, charcoal beds were employed abroad and the use of activated carbon in conjunction with sand filters was introduced in England many years ago by the Candy Filter Co. of England. Perhaps the most extensive studies of activated carbons in this country have been those made by Baylis. Additional observations have been made by Behrman, Weston and Norcom and G. R. Spaulding.

Baylis first demonstrated on a small scale the remarkable properties possessed by certain activated carbons, particularly a commercial brand known as "hydrodarco," in removing chlorine and by-product tastes. Apparently it is desirable to superchlorinate the water and remove the chlorine excess by activated carbon rather than to depend upon the by-product taste compounds being removed continuously, with the risk of some of these tastes passing through the filter. The excess chlorine aids somewhat in keeping the carbon activated.

From present available data a "Hydrodarco" carbon filter bed, 24 in. deep, will remove between 1 and 1.5 p.p.m. residual chlorine continuously for 11 months or more, before re-activation becomes necessary; that is, before enough free chlorine passes through the bed to be objectionable. These findings give a surprisingly long period of service for a carbon bed which was operated at a rate of 2 gal. per square foot per minute.

To date there is no record of a municipal carbon filter installation in America. There are one or two in Germany of recent installation. They have been entirely successful and the filters have required regeneration about every three months by steaming out. Important experimental observations have been published in Germany by Imhoff and Sierp.

There are, however, in the United States, a number of bottling plants which have used successfully activated carbon filters. Food products establishments are installing them and one hospital is on record as intending to superchlorinate and de-chlorinate its water supply by this method to produce a sterile water supply for the building.

The process should possess a particular appeal to the smaller municipalities, which may not have careful supervision of chlorine treatment of the public supply. In such instances overdosage could be the usual method, with removal by-carbon filtration of excess chlorine and resulting taste compounds after relatively short contact with the chlorine. Improved palatability of the water should result.

Correction of Corrosion Difficulties.—In this field, as in others, great progress has been made in the last ten years in making use of knowledge which in some instances was available a number of years prior. Again application of known principles and the development of new techniques wait upon public demand. When this demand becomes insistent enough old procedures are rediscovered and new ones are added. Some 20 years ago D. D. Jackson used soda-ash to correct corrosion troubles at Long Beach, L. I., N. Y. Tillmans, many years ago, studied the mechanism of corrosion and pointed out the importance of dissolved oxygen, carbon dioxide, and hydrogen-ion concentration. In 1912, Hale made extensive studies on the importance of dissolved oxygen in corrosion and of the secondary importance of carbon dioxide. He reported upon his findings in the "American Journal of Public Health" in 1913, Vol. 3, page 1337.

The first use of sodium silicate in a municipal supply in this country was in 1923 by Weston, to correct difficulties with lead solution. Speller's work in 1923 deserves special mention as clarifying the mechanism of pipe corrosion and suggesting means for correction. His comments on the importance of dissolved oxygen and pH and of the effect of temperature and velocity of flow through the pipes have done much to make more intelligent the control of this problem. Scientific application of chemicals to prevent corrosion were made in the use of lime by Hechmer at Hyattsville, Md., by Baylis at Baltimore and by Watkins at Norfolk, Va. About the same time the use of caustic soda for this purpose was introduced at Charleston, S. C., and at the West Virginia Pulp & Paper Co. plant at Luke, Md.

More extensive studies were carried out in New York by Hale in 1928, in order to determine the effect of various chemicals in the prevention of corrosion on steel, brass, lead and wrought iron pipes. In his studies, soda ash, silicate and lime, under hot and cold water conditions, were employed.

In general, it may be stated that corrosion difficulties in most instances may now be corrected with economy. Sufficient information is available to present an understanding of the chemical balance of the water supply necessary to avoid corrosion. A convenient index of the probability of corrosion is afforded by the dissolved oxygen reduction in portions of the distribution system. Elimination of carbon dioxide by aeration or by the application of chemicals or by both is a practicable procedure. The establishment of a chemical balance adequate to protect distribution pipes is feasible. No longer is it necessary to distribute a water through a distribution system with resulting destruction of the pipe carrying the water.

As C. P. Hoover recently points out: "Simple tests for determining equilibrium or chemical balance have been devised. It is possible to determine easily whether water delivered to consumers is saturated, supersaturated or undersaturated with calcium carbonate. This is done by adding calcium carbonate to the water in excess. If the water is undersaturated, the alkalinity will increase; if saturated, it will remain constant; if supersaturated, it will decrease. Water that is supersaturated with calcium carbonate will deposit a coating on the inside of pipes, and if continued too long the pipes will become clogged. On the other hand undersaturated water may cause corrosion."

Water Softening. — The American public has been slow in taking advantage of knowledge existing for almost a century as to how to reduce the soap consuming constituents of the water supply. A process for softening water was invented by Clark, a Scotch chemist, in 1841. Progress in the introduction of the process, however, has been very slow, apparently due to lack of understanding on the part of the public, both as to the needs for softening and as to the available economical procedures. One of the first municipal

plants installed in this country was in 1901 at Winnipeg, Man., where almost 30 years ago, it is interesting to note, re-carbonization using carbon dioxide from burning coke was developed and applied by J. O. Handy, then chief chemist of the Pittsburgh Testing Laboratories.

The first municipal softening plant apparently was at Oberlin, O., and was placed in operation in 1903. Although the excess lime treatment has been previously used in industrial and railroad water softening practice, the first application to municipal softening practice was made by C. P. Hoover at Columbus, O., in 1908. The process resulted in softening water and in higher bacterial reduction, with the use of re-carbonation. The value of the excess lime treatment was first pointed out by Sir Alexander Houston. In 1918, Youngstown, O., began the use of excess lime, in this instance, however, for the definite purpose of increasing the bacterial destruction and in order to avoid the use of chlorine on a water containing a number of industrial wastes of taste producing character.

The first large scale use of re-carbonation, that is, the application of carbon dioxide to a water chemically softened in order to avoid the deposition of lime products in filter beds, distribution lines and service pipes, was at Owensboro, Ky., in 1912. Interest in this process lagged, however, until about 1921 when C. P. Hoover gave additional emphasis to its value. The first large scale application of the process was at Defiance, O., at about this same time.

A similar revival of interest has occurred in the use of the zeolite process which was recognized and patented in England in 1896. Apparently zeolite material was first artificially produced in America by Gans in the form of "permutit" in 1913.

Zeolite is sodium aluminum silicate, but becomes calcium magnesium aluminum silicate after hard water is passed through it. It may then be regenerated or reverted to sodium aluminum silicate by backwashing it with a solution of common salt (NaCl). The hardness of water when passed through active zeolite softeners at proper rates is reduced to practically zero.

Although it was used primarily in industrial plants, within the last two or three years considerable interest has been created in its application to large municipal plants. Installations within the past two years have been made at the municipal plants at Sewickley, Pa., and at the Ohio Valley Water Co. plant near Pittsburgh, Pa. The advantages of the process appear to be in the simplicity of control due to the fact that only one chemical is needed, common salt; changes in hardness of raw water are not subject to manipulation and control on the part of the operator and there is no sludge. On the other hand, the water passing through a zeolite softener must be clear and softened water contains residual sodium bicarbonate which in some instances may create difficulty.

An interesting variation of the use of the zeolite principle is at the Bremen, O., plant, where both ferric and ferrous iron are removed from the water, in addition to producing a reduction in hardness.

C. P. Hoover has within the past year made another important contribution to the practice of water softening in pointing out the advantage of using excess lime, carbonation and return sludge in the water softening process. By this plan he has succeeded in reducing the carbonate hardness of all types of water and under all temperature conditions to almost the theoretical limit of solubility, that is, to less than 20 p.p.m. This accomplishment is of great practical importance, in as much as until recently an average reduction of carbonate hardness to 50 or 60 p.p.m. was considered excellent, with many softened waters frequently producing 85 to 95 p.p.m. of hardness after softening.

Perhaps the outstanding feature of inportance in the water softening field is the neglect of the general public in insisting upon its wider use. Buswell has recently pointed out that in Illinois every public supply should be treated for the removal of hardness and yet in that state only 1 per cent of the municipalities have water softening plants. Probably not over 10 per cent of the water supplies in this country which should be softened are subjected to that treatment. The economic waste due to this fact is great. Simple and economical processes are available. Why are they not used?

Iron and Manganese Removal.—The recognition of the importance of removing minute quantities of manganese in waters is relatively of recent origin. The removal of iron, however, has been given a great deal of attention in the past, although the number of installations is still small. Practically all the earlier installations depended upon aeration and filtration through contact beds of gravel, charcoal or cinders for the deposition and removal of iron and manganese. Weston was one of the pioneers in the development of these processes. Pirnie in 1923 pointed out that excessive aeration was undesirable and that contact beds of gravel with upward flow give satisfactory iron removal results. Installations of this character are in use since that time at Long Beach N. Y., Stuart, Fla., and Punta Gorda, Fla.

In 1924, Baylis added to the knowledge of manganese removal by his studies at Baltimore, where he found that increased pH, accompanied by the addition of lime and iron in coagulation, proved more effective in the removal of manganese than by the use of alum. Pre-chlorination apparently was also helpful. The experimental observations by Donaldson at Memphis, Tenn., in 1921, have established quantitative standards for the removal of dissolved gases by aeration and by contact cinder beds in trays.

Kuhr's observations on biological aspects of manganese removal in Holland in 1927, although still controversial, have added to the interest in this problem. His studies on the effect of manganic oxide in absorbing manganates from super-chlorinated water by contact with manganese dioxide are of great interest.

Practical control of manganese deposits and manganese mud balls in filters has been accomplished by Derby in 1928 at Beverly Hills, Calif., by super-chlorination of the beds and 12 hours standing at intervals.

Development in Analytical Methods and Laboratory Control.—A summary of the contributions in this field is by no means simple, largely due to the fact that many of the procedures are still under discussion, some are under attack and some have limited application. It is useful, however, to refer to the more important of these procedures for purposes of record. This is particularly desirable in view of the extensive operations during the past five years of Committee No. 1 of the American Water Works Association which deals with standard methods of analyses.

The studies in 1926 by Buswell and Boruff on ortho-tolidin and starch iodide methods for residual chlorine determination have been of great practical importance. Enslow and Tiedeman have made similar observations.

In the field of boiler water analysis the development by Bardwell in 1926 of a rapid method for determining various types of hardness in boiler water has facilitated industrial and railroad water softening control to a considerable extent.

Since 1928, important contributions in this field may be summarized as follows:

(a) The development of an important and accurate method for phenol determination by Gibbs and its modification by Baylis for appliaction in the sanitary field.

(b) The procedure for bi-chemical oxygen demand determination has been much more carefully studied and accordingly improved under the leadership of Mohlman in this country and Sierp in Germany.

(c) Considerable emphasis has been placed upon improving the methods of detection of the B. Coli group of organisms. The development by Salle and Noble of direct plate methods for growing and counting B. Coli, although still in an experimental stage, is of great imprtance in pointing the way to future simplification of bacteriological water examination. Extensive work on selective dyes by Jordan, Hale, McCrady, Levine, Dunham and other workers

should lead in the near future to practical and valuable changes in standard tests for the B. Coli group.

(d) An improved method for estimating manganese has been proposed by Forman, in which manganese is oxidized in alkaline solution and orthotolodin is employed to produce a yellow color which may be compared with standards.

(e) Improved methods of measurement of suspended matter in water are being studied by Baylis.

Of general importance in this field has been the development in 1917 of the eosin-methylene-blue plate method for identification of B. Coli by Max Levine; the preparation and commercial development in 1921 of convenient pH standards; the preparation of standardized and economical dehydrated culture media in 1923; the development in 1924 by Hale of an electrolytic, colorimetric and volumetric determination of copper in water; improved methods of determination of iodine in water by McGlendon, Clark, Daniels and others in 1926; quantitative studies of phenols in water by Donaldson and Furman; the use of chlorine demand of a water as an indicator of organic content by Froboese in 1920, Keiser in 1926 and Meadow and Hale in 1927; the development of the orthotolidin methods for dissolved oxygen determination by McCrumb and others in 1929; and the development of a technique for measuring hydrogen sulphide by Salle and Reinke in 1929 by the use of antimony sulphide with colorimetric comparison with standards.

Acknowledgment.—The foregoing is an abstract of a paper presented June 3 at the 50th annual convention of the American Water Works Association.

Automatic Water-Level Indication by Telephone

The water elevations of the filtered-water reservoirs of the Washington, D. C., water supply are plumbed in a novel manner, described by Dewey M. Radcliffe, associate engineer, U. S. Corps of Engineers, Washington, D. C., in a paper presented before the St. Louis convention of the American Water Works Association. Each reservoir is provided with an automatic level indicator, which, by means of a standard Bell telephone subscriber's station, will transmit the water level to any telephone connected to the system. The following description is abstracted from Mr. Radcliffe's account.

In a small building on the site of each of three reservoirs in widely separated sections of the city, a complete water-level indicator and transmitter, with all of its equipment, is installed.

It consists chiefly of three parts: a relay operated by telephone-ringing current, furnished by the telephone company; a cabinet, housing miscellaneous relays and selector switches, attached to the front of which is an ordinary desk-type telephone instrument with a swinging arm supporting a small loud speaker directly in front of the telephone transmitter, and a float-operated selector switch connected by a multi-conductor cable with the housing cabinet. Other types of indicators were studied but eliminated, due to the long distances between reservoirs and filter plant and pumping stations, and to the high cost of line construction or line-leasing cost. This led the engineers to select a device which would operate over the standard telephone at the regular subscriber's monthly rate and insure 24 hours' reliable service per day. This type of indicator allows any official of the water supply system to check the condition of the reservoirs from any point.

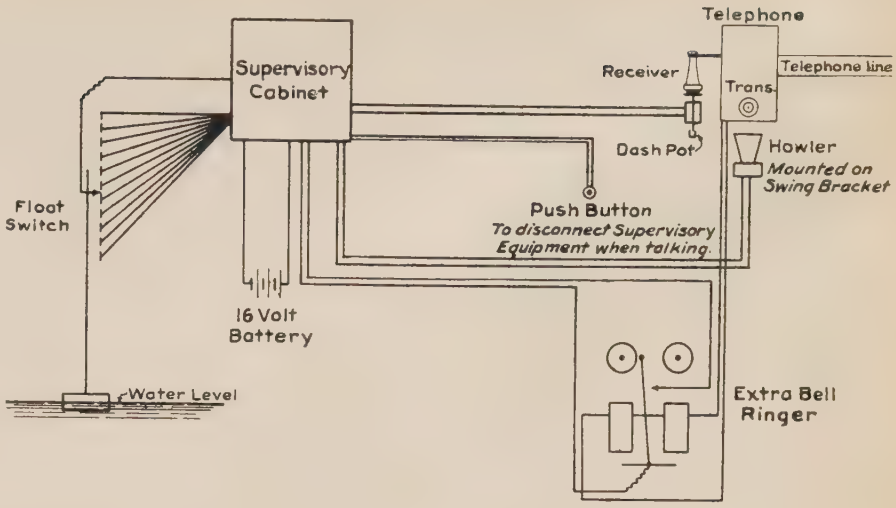


Diagram of Telephone Water-Level Indicator

The indicator does not interfere in any way with the electrical operation of the telephone circuit, as only sound is transmitted and no electrical connections are made to the telephone circuit.

The automatic operation is started by giving a stated telephone number to the operator, who rings the number called, causing the relay in the transmitter house or reservoir site to operate, thus energizing the various relays and switches of the transmitter. These cause an electromagnetic device, in the form of an arm coming through a small aperture in the housing cabinet, to lift the receiver and hook of the telephone and hold the receiver in off-hook position until the signal has been transmitted, after which the magnet is de-energized and the receiver is returned to normal on-hook position. The indicator operates equally well on the dial telephone system. In this case the telephone number of the indicator is dialed in the usual way.

When the receiver is lifted, a selector switch in the housing cabinet causes a series of buzzes to be originated; these are amplified by an audio-transformer, and passed through the small loud speaker, called the "squawker," mounted in front of the transmitter. The number of buzzes corresponds to the position of the float-operated selector switch—in this case the depth of the water, in feet, contained in the reservoir. The signal is repeated so that the person receiving the indication can confirm the original report, after which the receiver is restored to normal, as mentioned above, and the complete mechanism is in position to record the next call.

The telephone instrument used in conjunction with the water-level indicator may be used without any alterations or changes for ordinary talking purposes by merely lifting the receiver from the hook and swinging the small loud speaker out of position. At the conclusion of the conversation, the loud speaker will automatically swing back to position in front of the transmitter.

A delayed action of the starting relays is employed so that the equipment will only transmit upon a sustained ringing indication, as normally transmitted by the automatic telephone ringer. This eliminates all possibility of the mechanism being affected by lightning or other interference on the telephone wires.

These instruments have been used by the U. S. Corps of Engineers in Washington, D. C., for two years, in connection with the development of their new filtration plant at Dalecarlia, D. C., under supervision of Maj. Brehon Somervell, U. S. district engineer, assisted by Edward D. Hardy, principal engineer, and P. O. Macqueen, civil engineer. They have given 24 hours of unfailing service every day during this period.

The telephone water-level indicator was designed and developed by Mr. Radcliffe. The equipment was manufactured by the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Sewage Sludge Used by City Parks

Dried sludge from the sewage treatment plant at Lakewood, O., is stockpiled and used in the city parks. The sludge is used in plantings and is mixed with soil for use on the fairways of the public golf course.

Water Company Rules and Regulations

An Excellent Procedure for Governing the Relations Between the Utility and the Consumer

NOTHING is more important to a water company than that its rules and regulations for the guidance of its customers should be reasonable, comprehensive and readily understandible. A very excellent set of rules, which should be of considerable interest to any water company, is given in a recent decision of the Pennsylvania Public Service Commission in the case of the Snow Shoe Water Co. The company was ordered to file, post and publish the rules, which were as follows:

Application for Service.—1. Service connection will be made, and water will be furnished, upon written application by the prospective consumer (or his properly authorized agent), on a blank prepared by the company for this purpose, and after the approval of such application by the company. The application for service shall in general clearly outline the class, scope and type of use to be made of the service, as well as the purpose for which it will be used.

2. The application and these rules and regulations constitute the contract between the consumer and the company; and each consumer, by the taking of water, agrees to be bound thereby.

3. A new application must be made to, and approved by, the company upon any change in the identity of the contracting consumer at a property, or in the service as described in the application, and the company may, upon five days' notice, discontinue the water supply until such new application has been made and approved.

4. Each application for service shall be made in conformity with and stating the basis of rates applicable to consumers under the tariff provisions.

Service Connection.—5. The company will make all connections to its mains, furnish, install and maintain all service lines from the main to and including the curb cock and box, which shall be placed from one to two feet inside the curb line, all of which service line shall be the property of the company and shall be accessible to and under its control; with the exception of public fire hydrants which may be installed and maintained at the expense of either party, as may be agreed upon.

6. All service lines from the curb to the house shall be of pipe approved by the company, laid at least 4 ft. below the surface of the ground and kept in good repair at the expense of the consumer.

7. No service pipes shall be laid in the same trench with the gas pipe, sewer pipe or any other facility of a public service company, nor within 3 ft. of any open excavation or vault.

8. There shall be placed in the service pipe, within the wall of the building supplied, and so located as to drain all of the pipes in the building as well as the meter, a brass, lever handle stop and waste cock, easily accessible to the occupants, for their protection in enabling them to turn off the water in case of leaks and to drain the pipes to prevent freezing.

9. Hereafter in all future installations or re-installations of service lines, only one property will be supplied through one service pipe. Where more than one property is now supplied through one service pipe, and under the control of one curb cock, any violation of the rules of the company by either or any of the consumers so supplied shall be deemed a violation as to all, and the company may take such action as could be taken against a single consumer, except that such action shall not be taken until the innocent consumer, who is not in violation of the company's rules, has been given a reasonable opportunity to attach his pipe to a separately controlled service connection according to Rules 5 and 6. Whenever a service pipe supplying two or more consumers may for the purpose of stopping leaks or making other repairs, require the main stops to be closed it will be replaced by a separate service line with curb cock and box for each supply according to Rules 5 and 6. Where one service pipe has been used for two or more properties held in one ownership, and there be a division of such ownership, whether by sale or otherwise, each property will, thereafter, have its own service pipe according to Rules 5 and 6.

10. All leaks in service lines from the curb to, and in and upon, the premises supplied shall be promptly repaired. On failure to make such repairs with reasonable dispatch the company may turn off the water and it will not be again turned on until all proper and necessary expense incurred in shutting off and turning on the water, are paid in full.

11. The company shall in no event be responsible for maintenance of, or for damage done by water escaping from, the service pipe or any other pipe or fixture on the outlet side of the curb cock; and the consumer shall, at all times, comply with state and municipal regulations in reference thereto and shall make any changes thereon required on account of change of grade, relocation of mains or otherwise.

Use of Service Must Be in Accordance with Application and Contract.—12. The use of water service by a consumer shall in general be in accordance with the class, scope and type of use, and the purpose stated in his application and service contract. A consumer shall not use or allow use by others of water service through his service facilities for others or other purposes than covered in his application. (See Rule 34.) A new application and contract will make service for other purposes, or character of use, available.

Availability of the Different Classes of Service and Rates.—13. The various classes of service and rates are available to a consumer in accordance with the obvious intent of, and statements as to application made under the different rates in the schedule of rates.

Flat Rate Consumers.—14. Charges will be made for all water outlets or other facilities for utilization of service on the consumer's premises, except such outlets or facilities as have been disconnected or dismantled to the satisfaction of the company, or as provided in Rules 15 and 32.

15. For installed hose connections, hot water, heating plant or steam heating plant, within the period the service contract is in force and within the year, charges will be made from April 1 to April 1; because rates for these types of service are based on a seasonal use, which is usually only a fraction of a year, and the charge is divided equally among the four quarterly bills of the year. Therefore charges shall begin or cease on these items the preceding April 1 or the following April 1 for any such facility installed or dismantled, respectively; provided the charges shall not cover any period outside of the consumers service contract period.

Metered Consumers.—16. Each metered rate consumer's service shall have a separate meter to register the amount of water consumed, except as provided in Rule 50.

17. Railroad tanks, public garages, hotels and school houses will be supplied at meter rates only.

18. All meters will be furnished by, and remain the property of, the company and shall be accessible to and subject to its control. They shall be conveniently located within the building supplied, at a point approved by the company, so as to control the entire supply; and a proper place and protection therefor shall be provided by the consumer.

19. In any case where it is not convenient to place the meter within the building, as provided in Rule 18, the company may place it outside the building in a concrete or brick vault provided with a suitable cover and lock and key. Said vault shall be built inside the property line at the expense of the consumer.

20. In all cases where steam or hot water under pressure is used, a swing check valve must be placed, at the expense of the consumer, directly ahead

of the meter and before any outlets are taken off from the service pipe, to prevent injury to the meter.

21. Meters will be maintained by the company as far as ordinary wear and tear is concerned but the consumer shall be responsible to the company for any injury to, or loss of, any meter arising out of or caused by, the consumer's negligence or carelessness, or that of his servants, employees, members of his household, or any person upon his premises under or by his consent or sufferance. The consumer shall permit no one, not an agent of the company or otherwise lawfully authorized so to do, to remove, inspect or tamper with the company's meter, or other property of the company on his premises.

22. The quantity of water recorded by the meter shall be conclusive on both the consumer and the company, except when the meter has been found to be registering inaccurately or has ceased to register. In either case the meter will be promptly repaired by the company and the quantity of water consumed shall be estimated by the average registration of the meter on previous corresponding periods.

23. In case of a disputed account involving the accuracy of a meter, such meter shall be tested, upon the request of the consumer, in conformity with the provisions of the rules and regulations pertaining to Water Service Utilities of the Public Service Commission of the Commonwealth of Pennsylvania. In the event that the meter so tested is found to have an error in registration of 4 per cent or more, the bills will be increased or decreased accordingly as provided by the aforesaid rules.

24. Each request for the test of a meter for accuracy shall be accompanied by a deposit, the amount of which shall be determined by the size of the meter as set forth in the rules and regulations pertaining to Water Service Utilities of the Public Service Commission of the Commonwealth of Pennsylvania. If the meter so tested shall be found to have an error in registration of less than 4 per cent, the deposit shall be retained by the company as compensation for such test; if the error in registration is found to be 4 per cent, or more, then the cost of the test shall be borne by the company and the amount of the deposit shall be returned to the consumer.

25. The consumer shall at once notify the company of any injury to, or of any cessation in registration of, the meter as soon as it comes to his knowledge.

26. Each meter rate consumer is subject to a minimum charge, the amount of which is determined by the size of the meter as set forth in the schedule of rates.

Bills.—27. Flat rate service bills are due and payable quarterly at the office of the company on the first days of January, April, July and October of each year, covering service rendered during the previous three months.

28. Bills for water service for building purposes, are payable and due after service is rendered and upon presentation.

29. Bills for water service, under "general metered service" rates, will be rendered as soon after the first days of January, April, July and October of each year as it is possible to read the meters and make out the bills. Said bills will be for water consumed during the preceding three months and are due and payable upon presentation.

30. Bills for water service, under "metered service to extra large consumers, on night draft only," will be rendered as soon after the first day of each month as it is possible to read the meters and make out the bills. Said bills will be for water consumed during the preceding month and are due and payable upon presentation.

31. A penalty of ten (10%) per cent will be added to all bills for water service not paid within 15 days from the due date of the bill and if not paid within 30 days from the due date of bill, the water may be shut off upon five days' notice. Payments mailed, as evidenced by the United States post-office mark, on or previous to the end of the 15-day or 30-day period will be deemed to be a payment within such period. All bills will be made out in the name of the consumer whom the company will hold responsible for their payment.

32. Whenever the consumer desires to have his service contract terminated or his water service discontinued he shall notify the company to that effect in writing. The consumer will be responsible for the payment of all service rendered by the company until such written notice is received; and, in the instance of meter rate service, a reasonable time from the receipt of such notice shall have elapsed for the company to take the final reading of the meter or meters; or water service is actually otherwise discontinued by the company.

33. The presentation or non-presentation of a bill shall not be held to be a waiver of any of the above rules.

General.—34. The water may be shut off from a consumer failing to comply with these rules and will not be again turned on until satisfactory assurance is given that these rules will be complied with and all proper and necessary expense incurred in shutting off and turning on the water, are paid in full.

35. The company reserves the right to require a deposit in amount equal to the estimated billing period charges, to secure future payments where the credit of the consumer has not been established to the satisfaction of the company. Upon such deposits the company will pay interest at the rate of 6 per cent per annum, provided the deposit remains with the company for six months or more, and the company will return such deposit on notice to discontinue service and payment in full for all services rendered.

36. All waste of water is prohibited. A consumer shall keep his faucets, valves, hydrants, service lines and hose in good order and condition at his own expense. Sprinkling of any kind whatever must be done with ordinary spraying nozzles generally in use.

37. The water will, after due notice, be shut off from a consumer allowing it to run to prevent freezing, or allowing it to run to waste, and will not be again turned on until satisfactory assurance is given that the practice will be discontinued and all proper and necessary expense incurred in shutting off and turning on the water are paid in full.

38. When premises will be temporarily unoccupied, the consumer shall notify the company in writing and the water will be turned off and all charges will cease from that date. When the property is again occupied the consumer shall again notify the company in writing and the water will be turned on. No refund or allowance will be made for unoccupied property when written notice, both at time of vacancy and at time of occupancy, has not been given as above provided. No refund will be allowed for property unoccupied for a period of time less than one month.

39. In cases of vacancy of a consumer's property, the consumer must notify the company in writing of such vacancy, and upon his failure so to do he will become responsible for any damage to the property of the company, arising from such failure.

40. Water shall not be turned into any premises, by any person not an agent of the company, except temporarily by a plumber to enable him to test his work, provided it shall be turned off again immediately after the test is made.

41. The authorized agents of the company shall have the right of access, at all reasonable hours, to the premises supplied with water for the purpose of reading meters, examining pipes and fixtures, observing manner of using water, and for any other purpose which is proper and necessary in the conduct of the water company business, and will carry with them proper credentials denoting their employment by the company.

42. The company will not be liable for any claim or damage arising from a shortage of water, the breaking of machinery or other facilities, or any other cause beyond its control.

43. As necessity may arise in case of break, emergency or other unavoidable cause, the company shall have the right to temporarily cut off the water supply in order to make necessary repairs, connections, etc.; but the company will use all reasonable and practicable measures to notify the consumer,

in advance, of such discontinuance of service. In such case the company shall not be liable for any damage or inconvenience suffered by the consumer, nor in any case for any claim against it at any time for interruption in service, lessening of supply, inadequate pressure, poor quality of water, or any cause beyond its control. The company shall have the right to reserve a sufficient supply of water at all times in its reservoirs to provide for fire or any other emergencies and may restrict or regulate the quantity of water used by consumers in case of scarcity, or whenever the public welfare may require it.

44. Water from hydrants or other protection systems shall be used only in case of fires, except that water from public fire hydrants may be used, in a reasonable amount and at such times as the company may permit, for the purpose of testing the hydrants and the fire fighting apparatus of the Borough of Snow Shoe, such tests to be conducted only by the properly authorized agents or employees of said borough and after the consent of the company has been obtained.

45. No consumer, unless specially authorized to do so, shall open or close any of the company's stop cocks or valves in any public or private line.

46. No agent or employee of the company shall have the right or authority to bind it by any promise, agreement of representation contrary to the letter or intent of these rules and regulations.

47. The company reserves the right to alter or amend these rules and regulations in the manner provided by law.

Definitions.—48. The word "company" as used herein, shall mean the Snow Shoe Water Company acting through its properly authorized officers, agents or employees, each acting within the scope of the particular duties entrusted to him.

49. The word "consumer," as used herein, shall mean the party contracting for a supply of water to a property as hereinafter classified, i. e.:

(a) A building under one roof and occupied as one residence or business; or

(b) A combination of buildings in one enclosure and occupied by one family or business; or

(c) One side of a double house having a solid vertical partition wall; or

(d) One side or part of a house occupied by more than one family or business, even though the closet and other fixtures be used in common; or

(e) Each apartment, office or suite of offices located in a building having several such apartments, offices or suites of offices and using in common one hall and one or more means of entrance.

50. Each consumer will be supplied through a separate service line and, if on a metered basis, through a separate meter, except in cases (d) and (e), as above defined, in which cases each family, office, suite of offices or business shall be considered a separate consumer even though supplied through a common service line or meter.

Hackensack Water Co. Abolishes Collectors

The Hackensack Water Co. no longer uses collectors. A new system of collecting water bills, replacing the old and outworn method of personal visitation, has been adopted, it is announced by the president of the company, Nicholas S. Hill, Jr. This departure, Mr. Hill explained, respects both public integrity and sound business practice.

"Supplying water for domestic and industrial uses is a commercial enterprise fairly comparable to retail merchandising," he said. "In modern business very few merchants collect their bills by regularly sending collectors to their customers. The majority of householders meet their obligations promptly, and object to calls by collectors.

"Naturally water service has its credit problems, but these the company is solving through a procedure that is neither harsh nor arbitrary but rather invites a frank response from all classes of the community.

"In general the company believes that most of its customers wish to pay their bills with reasonable promptness, in their own way, at the company offices.

"An added convenience for customers is the cooperation of local banks in communities which are some distance from one of the company's district offices. There are 23 such banks at which water bills may now be paid, and each customer is told where the bank most convenient to him is situated. Last quarter 8 per cent of the bills were paid at neighborhood banks.

"If a bill is not paid within the period usually allowed as reasonable by business houses, the customer receives a statement or a notice from the company. In most cases the response of customers to this statement is prompt.

"An investigator may be sent to call upon a customer if there are any unusual matters reported in connection with the account or with the service.

"However if no word or payment is then received from a customer, he will receive in due course a letter from the company's attorney. Then, if finally necessary, suit will be started."

The chief advantages of the new system, according to Mr. Hill, are:

First, that under a regular schedule of dates every customer has ample time in which to pay his bill or to communicate with the company.

Second, no unnecessary or annoying calls are made at customers' premises.

Third, the old system of cutting off service has been stopped in all cases except where every other method of inducing a customer to pay for service received has been tried and has failed.

"This company," Mr. Hill added, "believes that water service is vital to all persons, and that to discontinue such service is too harsh a procedure except in the very few extreme cases now arising.

"Our customers who think this matter through know that anything which makes enforced collection of accounts neessary is a source of annoyance and additional cost both to the customers who do not pay and to the company.

"Our experience so far, and the reports from other places where the present system has been in effect for some years, show that the new way is receiving favorable comment and support from the people."

Sewage Treatment at Columbus, O.

The following is extracted from the 1929 report of the Division of Sewage Disposal, C. D. McGuire, Chemist in Charge, of the city of Columbus, O.:

"The treatment works operated 187 days and treated 5,604 million gallons, or practically 30 million gallons of sewage per day. This is a 50 per cent overload based upon the volume for which the filters were designed and about 100 per cent more than they will treat successfully based upon the present stream flow conditions, past experience and present requirements of the State Health Department.

"The tanks removed 80 per cent (by volume) of the settleable material and 53.4 per cent (by weight) of the total suspended solids from the raw sewage. The retention period in the tanks was 3.9 hours and they reduced the biochemical oxygen demand 30.6 per cent.

"The sprinkling filters retained 17.8 per cent of the suspended solids applied (5.7 less than in 1928), decreased the biochemical oxygen demand 60.1 per cent and produced 3.0 parts per million of nitrogen as nitrites and nitrates in the effluent. The mean dose per acre was 0.12 m.g.d. higher than in 1928, but the filters were in service 2.3 per cent less of the time. The mean rate of dose per acre was 4.43 m.g.d. and was 0.28 m.g.d. higher than for 1928.

"The whole system reduced the total suspended solids 61.8 per cent and the biochemical oxygen demand 72.4 per cent.

"During the year the procedure for making the routine biochemical oxygen demand test was modified as follows: First, the dilution water was made up by dissolving 500 p.p.m. sodium bicarbonate in tap water which has stood at least 5 days at laboratory temperature and then placing this in a 37 deg. incubator until required for use. Second, the samples were incubated submerged in a bath of water at 20° C. These modifications have given a decided increase in the number of check results obtained by the test."

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor
Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

Two Questions on Sludge Digestion Answered

Is it necessary to use pumps to circulate the heating water through the coils used to maintain the temperature in sludge digestion tanks, or will the water circulate automatically by the difference in temperature as in the case of a house heating plant?

The water will circulate automatically by reason of the thermal difference, but it is preferable to use pumps in order to secure equivalent heat transfer at lower initial water temperature.

The reason for keeping the initial temperature down is to prevent baking sludge on the outside of the heating coil since such a coating will interfere with heat transfer.

There has been considerable talk about this insulating coating forming on the heating coils, but little positive information on the subject has been available, heretofore. Recently the writer has had the opportunity of inspecting two circular digestion tanks which had been heated by means of thermal circulation without the use of circulating pumps. Both tanks had been in use for some 3½ years and the conditions in the two were so nearly identical as to establish a valuable check on actual conditions.

There was 110 ft. of pipe in each coil and the initial temperature of the heating water was approximately 140° F. The water returning at the temperature of the sludge in the tank showed that the heat had all been absorbed.

The above conditions were maintained during all of the 3½ years during which the tanks had been in continuous operation, but when the sludge was drawn off for inspection it was found that at the "hot end" of the coil there was a coating or shell 5/16th in. thick which could be cracked off in rather large pieces and resembled a clinker cement. The thickness of the coating gradually diminished to zero near the "cold end" of the coil, all evidence indicating that formation of the scale had been progressive and dependent on the higher temperatures for its formation.

The outer surface of the scale was so irregular as to preclude accurate measurements but it may be said that roughly the thickness was 5/16th at the "hot end" 4/16th at a point 20 ft. from this end, 3/16th at 40 ft., 2/16th at 60 ft. and 1/16th at 80 ft. Beyond this point it dwindled off rapidly.

Several conclusions may be drawn from the facts observed: In the first place, it appears from the fact that at the end of the 3½ years the cold water returned at sludge temperature that the heat transfer was complete in spite of the fact that not more than 30 ft. of the coil still remained uncoated to an appreciable extent.

It would appear that the usefulness of the coil as a heating element would be eliminated in from 7 to 9 years by the progressive growth of the scale.

Had the initial temperature of the water been kept down around 110° F. or possibly a little higher there would have been very little baking on of the sludge. The same heat transfer could have been accomplished at the lower initial temperature by more rapid circulation of the heating water by means of pumps.

During the early studies of heat controlled digestion, this matter of heat transfer through heating coils was studied by the writer and it was found that, since the heating of the water is regenerative, high initial temperature of the heating water is not essential and speed of circulation within reasonable limits is not critical.

That is to say, the heating unit simply makes up the difference between the temperature of the water from which the sludge has absorbed the heat and the initial hot water temperature. An apt illustration of this point is afforded by data (Table I) from the investigation mentioned.

Table I

Minutes required for circulation through heater and heating coil	7	9	11	9
Initial temperature of heating water	105	105	105	120
Temperature of returned water	87	80	75	89
Difference in temperature Initial to final	18	25	30	31

Since the total circuit consists of the coils in the boiler for heating the water and the coils in the sludge (which cools the water), a longer period of time in one means a relatively longer time in the other and the processes of cooling and reheating balance up within reasonable limits. Where the fuel is gas and the temperature of the heating water is thermostatically controlled there seems to be little difference in economy.

The work described above was carried on with a rather inefficient second-hand hot water boiler of the shell type and a grid of 1¼-in. pipe 140 ft. long. From the results of the work it was determined that a coil of 2-in. approximating 110 ft. in length would suffice to heat a sludge tank of 20,000 cu. ft. capacity, or a single turn of pipe about the interior of a 38-ft. diameter tank. Many engineers have expressed surprise at the small amount of heating pipe used, but it has proved very effective.

A test of the heating coil in place before sludge was introduced into the tank gave additional enlightening data. Working without circulating pumps and depending on thermal currents for circulation we ran two series of tests, one with initial temperature of 154° F. and the other with initial temperature of 137° F. The tank cover was resting on legs about 5 ft. from the tank floor at the periphery of the tank so that in effect we had a circular room 38 ft. in diameter and an average of 6 ft. 6 in. deep. Within this space the air temperature was 83° F.

Starting with an initial temperature of 154° F. we found as we progressed around the coil, a temperature of 190° F. 40 ft. from the hot water end, 89° F. 80 ft. from the hot end; running off to room temperature 100 ft. from the beginning.

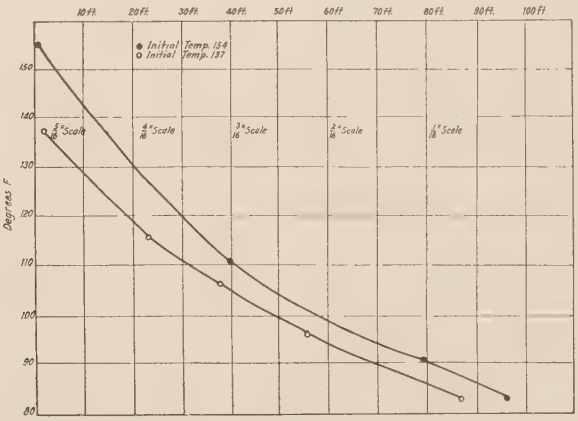
Starting with an initial temperature of 137° F. we obtained 116° F. at 22 ft.; 105° F. at 38 ft.; 95° F. at 55 ft. and room temperature about about 80 ft.

Note that room temperature—83° F.—approximates the optimum temperature for digesting sludge—82° F.—and that any lower temperature would absorb the heat more quickly; also had the coil been immerged in liquid, or sludge, the cooling would have been more rapid.

The attached graph indicates the conditions found in the two tests and also indicates the thickness of crust on the heating coil after 3½ years of service. The thickness of scale at any

point does not correspond to the indicated temperature but to some higher temperature, since the high temperature was carried forward in the pipe progressively as the insulating scale formed at the hot end.

Indications are that the provision of



Temperatures at Various Points in 2-In. Heater Coil in Digestion Tank (Room Temperature 83° F.)

110 ft. of 2-in. pipe for heating a tank of 20,000 cu. ft. capacity is ample; such a coil would serve its purpose for from 7 to 9 years at least, even if initial temperature of the heating water were as high as 140° F. before the incrustation on the pipe would seriously interfere. With initial temperatures as low as 110° F. and possibly as high as 120° F. the incrustation would be of no practical importance.

Delving into old records to answer the question in hand I find other interesting data which may as well be presented in this connection.

The "Digestion Tank" was simply an excavation 50 ft. square and 10 ft. deep, giving a total capacity of 25,000 cu. ft., and insulated by a cover of 2-in. pine planks. Without heating, the sludge temperature took exactly the same course as that in the digestion compartment of the Imhoff tanks, holding at 68° F. through the first week in October and dropping to 66° F. at the end of the month. By the end of November it was at 62½° F.; at the end of December it was 58° F. and the end of January 52½° F. By the middle of February it had reached a minimum of 50° F., where it remained until the 22nd, when heat was applied by means of the 140-ft. coil of 1¼-in. pipe.

From the time that we began to apply heat the temperature rose ½ deg. per day throughout the 24 days of the test. An average of 151 lb. of soft coal was used daily and 24 lb. of ash was removed daily, making the equivalent of 127 lb. of coal actually burned.

To raise the contents of the tank—25,000 cu. ft.—1° F. daily would require enough heat to raise 1,562,500 lb. of sludge 1 deg. daily.

Records of the differences in temperature in the heating water together with a calculation of the total flow of heating water passing any given point in the heating system daily indicate that the heat transferred was equivalent to raising 1,061,000 lb. of water 1 deg. per day.

Since 1,562,500 lb. of sludge were actually raised ½ deg. daily, equal to 781,250 lb. 1 deg. daily, we have the direct comparison on a practical scale of 1,061,000 deg.-lb. per day available —to 781,250 deg.-lb. actually corralled at the end of the 24-day period. The difference represents the losses of heat to ground and air. These losses equal 26.4 per cent.

It should be remembered that the sludge was in direct contact with the earth, there being no concrete or other retaining wall, and that the plank cover, floating on the surface of the sludge, did not completely cover the latter, as the earth cut was somewhat sloping, leaving 2 to 3 ft. of the surface exposed all around the edges. Undoubtedly a coating of lard-like grease from 1½ to 2 in. thick, which formed on the under side of the planks, aided in the insulation.

The attached graph indicates the air temperatures as well as the sludge temperature during these tests.

What pitch do you consider necessary for the floor of digestion tanks in order that solids will not lodge and take up valuable space?

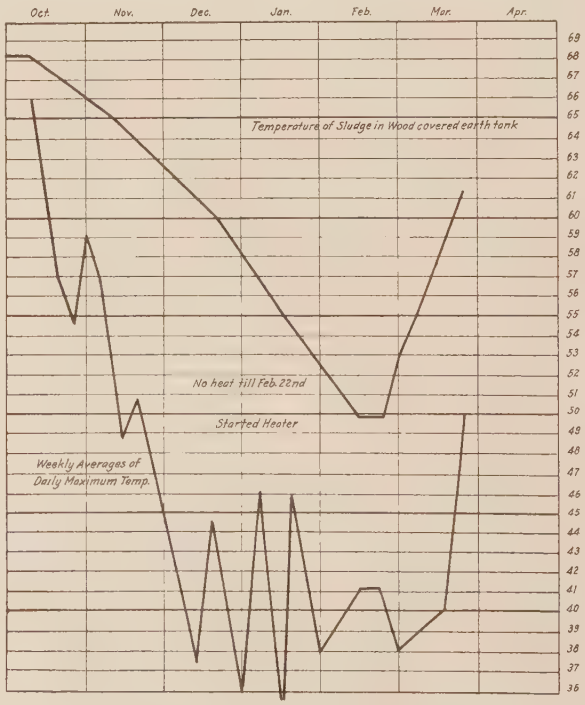
The answer depends on the sewage and the preliminary treatment and on what kind of a digestion tank you mean.

With sand and grit in a sewage it has been claimed that 60 deg. slopes are necessary. I have experienced difficulty with sand and grit collecting in Imhoff tanks where the slope was 1 vertical on 2 horizontal and when the preliminary treatment was not effective.

On the other hand working with separate digestion tanks under controlled conditions and where grit has been removed by screens and grit chambers I have experienced no difficulty, whatever, with a slope of 18 in. in 19 ft.

With heat controlling digestion gassing of the sludge is very active and gas lifted solids tend to be discharged near the gas dome where the ebulition is rather violent and to sink into quieter waters below. It takes but little strategy to place the sludge outlet beneath the gas dome and there you are.

The modern practice of installing screens and grit chambers in nearly every plant calls for a reconsideration of our old notions about the necessary slope, especially as steep slopes call for deep excavation and run into money. It is well to give consideration to the relative cost of grit chambers which allow of much less slope in the diges-



Data on Heating Sludge

tion tank floor. Even with strictly domestic sewage grit chambers should be given consideration and will usually be found economical.

In the case of two tanks recently examined which had been in service for 3½ years preceded by a fine screen and part of the time by a grit chamber, soundings revealed not more than 3 in. of loose grit on any part of the floor. This was so loosely packed that a rod or pipe penetrated easily to the concrete floor of its own weight. On drawing down these tanks after the 3½ years' service we found less than a yard of material which did not go out with the sludge, although the tanks had a capacity of 20,000 cu. ft. each and had treated an average of 400 cu. ft. of fresh sludge daily during the entire period of operation. These were the tanks mentioned above as having a slope of only 18 in. in 19 ft.

Annual Meeting New York State Sewage Works Association

The second regular annual meeting of the New York State Sewage Works Association was held in Albany, N. Y., on May 10. In the absence of the president, Kenneth Allen, the vice-president, C. A. Holmquist, presided. Sixty-one members and guests were present.

The morning session was devoted to the regular business of the association and to the presentation and discussion of two papers, one on "Operating Experience at the Syracuse Treatment Works," by W. P. Gyatt, chief operating engineer, and the other on "Essentials of Operation and Control of Small Sewage Treatment Plants" by C. C. Agar of the State Department of Health.

Wellington Donaldson (New York City), W. A. Ryan (Rochester) and C. L. Walker (Ithaca) were elected members of the executive committee for a term of three years to succeed the retiring members, R. Suter, R. H. Gould and Kenneth Allen. Mr. Allen, however, will continue to serve on the executive committee for another year as an advisory member. The officers for the ensuing year are C. A. Holmquist, president; Morris M. Cohn, vice-president, and A. S. Bedell, secretary-treasurer.

The report of the Committee on the Short School for Sewage Works Operators was received with considerable interest, as definite plans are being formulated for holding a one-week school at Schenectady during the coming autumn.

At the luncheon held in the DeWitt Clinton Hotel, Mr. C. A. Holmquist presented the greetings of Dr. Parran, the State Commissioner of Health, indicating his sincere interest in the aims and activities of the association. Following the luncheon, there was a lively round table discussion on the effect of industrial wastes on the operation of municipal sewage treatment plants, the propriety of allowing cellar drains to be connected to the sewer system and the specifications for house connections, led by R. S. Lanphear, R. C. Wheeler and Fred Fisch.

The meeting closed with an inspection trip to the sewage treatment plant of the city of Albany, and to the treatment works serving the Albany county buildings, where very complete treatment and odor control were well exemplified.

The next meeting of the association will be held on Sept. 6, 1930, in Syracuse, G. D. Holmes serving as chairman of the local committee on arrangements.

Treatment of Dairy Wastes

The Agricultural and Mechanical College of Texas, College Station, Texas, has issued recently a bulletin giving the results of a study of the treatment of dairy wastes, conducted by the Sewage Research Division of the Texas Engineering Experiment Station. The conclusions based on this study are summarize as follows in the bulletin:

Wherever possible a trickling filter rather than chemical methods should be used to treat dairy wastes. The advantages of the former methods are as follows:

(a) No preliminary treatment is needed except grit removal.

(b) Sludge and scum disposal is not a problem.

(c) A better effluent is obtained.

(d) Slight treatment can be given to prepare the waste for discharge into city sewers.

(e) A filter is more adaptable to fluctuations in the strength of the waste than is the chemical method.

(f) Skilled operation is not required.

(g) Operating cost will be slow.

A trickling filter 5 ft. deep operating at a 1.5 million gallon per acre per day or a filter 6 ft. deep operating at a 2 million gallon rate will produce a satisfactory effluent in the treatment of ordinary dairy waste (not including whey from cheese factories). At the 1.5 gal. rate a filter 3 ft. deep will give sufficient treatment for some purposes. (Note: These rates are based upon 24 hours operation per day. If the waste is discharged during 12 hours only the areadosage relationship must be changed accordingly.)

Sulphuric acid, alum, ferric chloride, and ferrous sulphate are of value (approximately in the order named) in precipating milk solids. With proper operation this method should produce an effluent suitable for discharging into streams or upon land without nuisance and without the necessity of chlorination. Sludge and scum will be a troublesome by-product, although that resulting from the sulphuric acid treatment could probably be used for feeding to hogs or chickens.

Supporting Strength of Concrete-Incased Pipe

The supporting strength of concrete-incased clay pipe as determined by the Iowa Engineering Experiment Station, Iowa State College, Ames, Ia., in co-operation with the Clay Products Association, Chicago, Ill., is reported in bulletin 93 of the experiment station.

It was found that the safe supporting strength of concrete-incased clay pipe is only slightly greater than the sum of the individual supporting strengths of the clay pipe and of the concrete incasement. The supporting strength of the incased pipe was found to be higher at lower temperatures. The action of an incased pipe is very nearly that of two independent but concentric rings, results indicated.

Tests indicated that the strength of a concrete specimen is influenced to a marked degree by the temperature at which it is tested. Specimens tested at 1° F. were found to have about double the ultimate strength of specimens made and cured under the same conditions but tested at 70° F.

Group Plan Insurance in Water Works Field.—Supervising Engineers, Inc., of New York City, a holding company for 42 water companies in the east and middle west has announced the expansion of its employes' group plan to include the benefits of $650,000 accidental death and dismemberment insurance combined with health and non-occupational accident insurance. The additional coverage is being underwritten by the Metropolitan Life Insurance Company. Individual benefits are based on salary, the dismemberment insurance ranging from $1,000 to $2,000 and the sick and accident benefits from $10 to $20 a week. These weekly payments will be made when an employe is unable to work due to sickness from any cause or injury received while off duty.

Reforestation by St. Paul Water Works.—Reforesting of the lands of the Water Department of St. Paul, Minn., continued during 1928 and 1929, work being confined mostly to replacements. Since 1914, when this project was started, there have been planted nearly 500,000 trees divided between White, Norway, Riga, Scotch, Swedish Scotch and Jack Pine; White, Norway, Red, Blue and Black Hills Spruce; White and Red Cedar and Balsam and Douglas Firs. While large numbers of trees have been lost from fire, theft and natural causes, a large percentage of the trees remain standing, some of the earlier plantings of Jack Pine having attained a height of 16.5 ft. in ten years. Jack, Scotch and Riga Pine have attained a height somewhat better than the average for these species throughout the Lake States.

Specifications for Drilled Wells

By W. SCOTT JOHNSON

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I WAS very much interested in the excellent article by Mr. Ferguson and Mr. Klassen on the "Sanitary Specifications and Construction of Water Wells," which appeared in the May issue of Water Works and Sewerage.

Five or six years ago many of the difficulties outlined in the above paper in securing satisfactory construction of well supplies were encountered in Missouri. Experience indicated that satisfactory specifications covering the sanitary features in well construction were of considerable aid in overcoming some of the difficulties. However, specifications covering all possible conditions to be encountered were not found practicable, since each well requires individual expert attention during its construction period. Granting that individuals in charge of drilling operations are thoroughly awake to the importance of proper sanitary well construction, there was still the factor of widely varying geological conditions encountered in Missouri which demanded expert technical supervision in order to assure safe and economical results.

In order to overcome this difficulty in the sanitary construction of well water supplies, a cooperative agreement was entered into between the State Board of Health and the State Geologist in 1925 that has proven most successful. Specifications were prepared covering the sanitary features of wells drilled in rock and the installation of well pumping machinery. All engineers are required to include these in specifications for the construction of municipal water supplies secured from wells. Copies of these specifications are enclosed.

In accordance with our agreement, the State Geologist is informed concerning a proposed well water supply and the driller is required to send a written notice to that office at least one week before operation is started. This gives the State Geologist an opportunity to advise with the driller concerning the probable conditions to be encountered, and also to supply a set of sacks for drillings and a drill record book. After drilling operations are begun the driller is required to secure cuttings from every screw, place same in sacks, label and send at once to the State Geologist. Also, all information concerning openings, fissures or soft or broken ground encountered is reported. From these data the State Geologist determines the depth at which it will be necessary to place the casing in order to exclude water of recent surface origin following solution channels and fissures in the rock. When the proper depth for setting the casing has been reached a field representative of the State Geologist inspects the job, supervises the sealing of the casing and checks the tightness of seal, as required by the specifications. After completion of the well all samples of cuttings secured after casing and the complete record book of log are forwarded to the State Geologist, who correlates same and furnishes the owner and the State Board of Health with a copy of the completed log of the well.

Upon completion of the entire job, including installation of the pump, etc., a final inspection is made by an engineer with State Board of Health to check for approval the sanitary features of the well top construction, including proper drainage of pit, if same is provided for, height of well casing above pit or pump room floor, well casing material, and the effectiveness of seal between drop pipe and casing. At this inspection samples are collected for bacteriological analysis at the State Board of Health laboratories and for complete chemical analysis by the State Geologist.

This plan has proven very successful in allowing for sufficient latitude relative to the depth of casing and at the same time to secure sufficient depth in order that shallow contaminated fissure water is excluded from the well supply. Incidentally, the data secured by the State Geologist has been of considerable value to him and has made it possible to prophesy the probability of securing a satisfactory municipal water supply from wells in many parts of the State. We believe that without this assistance from the State Geologist, particularly in setting the depth of casing, we can not be assured relative to whether or not this important point in the sanitary construction of a well supply has been properly provided for.

Recommended Specifications Covering Sanitary Features on Wells Drilled in Rock

1. **Samples of Cuttings.**—At least one week before starting to drill the well, the driller shall send a written request to the State Geologist, Rolla, Mo., who will furnish a set of small sacks and a drill record book. The well driller shall save a sample of cuttings from every screw and place same in the sacks, properly labeling same.

2. **Casing.**—The well shall be cased with a screw joint steel or wrought iron pipe installed in a watertight manner. The State Geologist will recommend the depth of casing advisable to effectively shut out contaminated surface water based upon available records. The casing shall be extended to at least this depth and deeper if necessary so as to case off all openings or soft or broken ground.

Where the water encountered is known or found to be corrosive, special provision shall be made to protect the casing from corrosion by a method approved by the State Board of Health; the contractor to receive extra compensation for same in an amount agreed upon in writing prior to undertaking the work.

The well casing shall be extended to a point from four or six inches above the elevation of the finished pump room or pump pit floor, and shall be provided with a thread at the top.

3. **Seal.**—A satisfactory seal shall be made or installed at the bottom of the casing, by one of the following methods:

a—Setting the bottom of the casing on a shoulder in the well made by reducing the size of the drill hole, and sealing with cement grout, a lead packer or drill cuttings of a cementing character.

b—Driving casing into clay, shale or similar sealing formation.

c—Installing an expanding rubber packer.

The seal shall be tested by bailing out the drill hole and making sure that there is no leakage into same over a period of forty-eight hours. When no appreciable amount of water has been encountered up to time of sealing, at least 1,000 gallons of water shall be run into the annular space on the outside of the casing to test the seal.

4. **Water Analysis.**—Where a water-bearing stratum, furnishing the required volume of water, is encountered at a satisfactory depth, samples of water shall be collected at the end of the test pumping run and submitted to the State Geologist or private chemist for complete chemical analysis, including the iron, manganese, and hardness content, to determine the suitability of the water for a general city supply.

5. **Records.**—The driller shall note in the drill record book the location and depth of any openings or soft or broken ground encountered, together with complete information on the depth of casing, method of sealing same, and result of test of seal.

Immediately on completion of the well, and prior to completion if requested, the driller shall forward all samples of cuttings and the drill record book to the State Geologist, who will correlate same and furnish the owner with a copy of the completed log of the well.

6. **Approval.**—These specifications shall be carried out in a manner satisfactory to the State Board of Health of Missouri, before this portion of the work is accepted.

Recommended Specifications Covering Sanitary Features in the Installation of Well Pumping Machinery

A. The use of a well pit or sub-ground level pump room shall be avoided wherever practicable on account of the possibility of stoppage of the drain or ejector and neglect to replace the well top seal after making repairs.

B. Where the pump is installed without a pit—

1. The pump shall be installed on a concrete base of sufficient height to permit the outside casing to extend at least 4 inches above the pump room floor, and to enable the installation of a suitable connection as noted under B-2.

2. The annular opening between the outside casing and pump column shall be closed by means of a suitable watertight connection which will effectually prevent waste water, oil, insects or other contaminating material from entering the well.

C. Where the pump is installed with a pit or in a pump room below the ground level—

1. The sides and bottom of the pit or pump room, below the ground level, shall be constructed of watertight concrete. The pit shall be left uncovered to permit easy inspection by the pump operator, and shall be surrounded by concrete curb at least 6 inches high and a pipe railing.

2. The annular opening between the outside casing and pump column shall be closed by means of a watertight connection capable of withstanding for 24 hours, without leakage, the water pressure resulting from complete filling of the pit with water. The types of connections approved are given below in order of preference.

a—An all flanged or threaded connection.

b—A stuffing box connection.

c—Metal to grouted cement connection with suitable gasket (not rubber); to be used only when joint carries weight of pump column and the pump is rigidly supported to prevent vibration.

Any vents provided for the well shall be extended by a pipe with screw or flange connections to a point above the floor level. A return ell shall be screwed on the upper end of this pipe, and screened.

3. Drainage shall be provided for the pump

pit or pump room by one of the following methods:

a—By means of a drain consisting of a sewer pipe, not less than 6 in. in diameter, with cemented joints, installed in a straight line and on an even grade of not less than 0.6 per ft. per 100 ft., with a concrete bulkhead at the outlet to insure an open discharge at all times; provided that under no conditions shall this drain receive sewage, or be connected to a sewer, and that the bottom of the pit so drained shall be above the high water level in any adjacent watercourse.

b—By means of a pump or ejector drawing from a sump of not less than 12 cubic ft. capacity situated so as to collect all waste water. This pump or ejector shall operate automatically or be connected to some moving part of the pump head, so as to operate continuously with this pump, and shall discharge above the pump room floor level into a suitable drain at a point safely removed from the pump pit or pump room.

4. The bottom of the pit or pump room shall be sloped away from the top of the well casing toward the drain or sump with sufficient grade to insure ready flow. At least six inches difference in elevation shall be provided between the top of the well casing and high water level in the sump.

D. A separate pump column, suction or discharge pipe shall be installed inside the well casing in all instances, whether the well is to be pumped by suction, air lift or deep well pump.

E. These specifications shall be carried out in a manner satisfactory to the State Board of Health of Missouri, before this portion of the work is accepted.

Canal Capacity Increased by Concrete Lining

The Sewage and Water Board of New Orleans, La., recently completed lining with concrete the Metairie Relief Canal. The work included the construction of a 6-in. cast-in-place sloping bottom, in some places resting on the wooden piling and wooden floor of the old lining, the casting and driving of a concrete sheet-pile wall and the building of many concrete structures which carry streets over the canal.

The work was done to increase the drainage capacity. Ordinarily that would mean the deepening and widening of the canal. But in New Orleans deepening a canal would enormously increase the infiltration and also the trouble with unstable banks. As all drainage water in New Orleans has to be pumped at least once it seemed better to get increased drainage by lining

Sheet Piling Was Driven by an Ordinary Steam-Hammer Pile Driver

the canal with concrete to speed up the flow by decreasing friction.

The Metairie Canal widens and deepens as it approaches the outlet, so its cross-section is variable. A typical section is 87 ft. wide with flood elevation at 22.87 and invert elevation 9.83. The mean gauge level of Lake Ponchartrain, the outlet for the canal, is 21.26 ft. The bottom section is 26 ft. wide and slopes from sides to center, 3 ft. in 13 ft. It consists of two slabs, 6 in. thick, reinforced with ⅜-in. round rods spaced 6 in. center to center in both directions. It rests on the old wooden canal lining of planks, wooden caps and wooden piles.

The next section on each side of the center is 13½ ft. wide and slopes 0.75 ft. in that distance. It is 6 in. thick and rests on the earthen side of the old canal.

The outer sections are 16 ft. 4 in. in horizontal section and rise 8.17 ft. in that distance, making a slope of 2:1. Each section was cast separately and is separated from sections above and below by a ¾-in. expansion joint, designed to prevent infiltration.

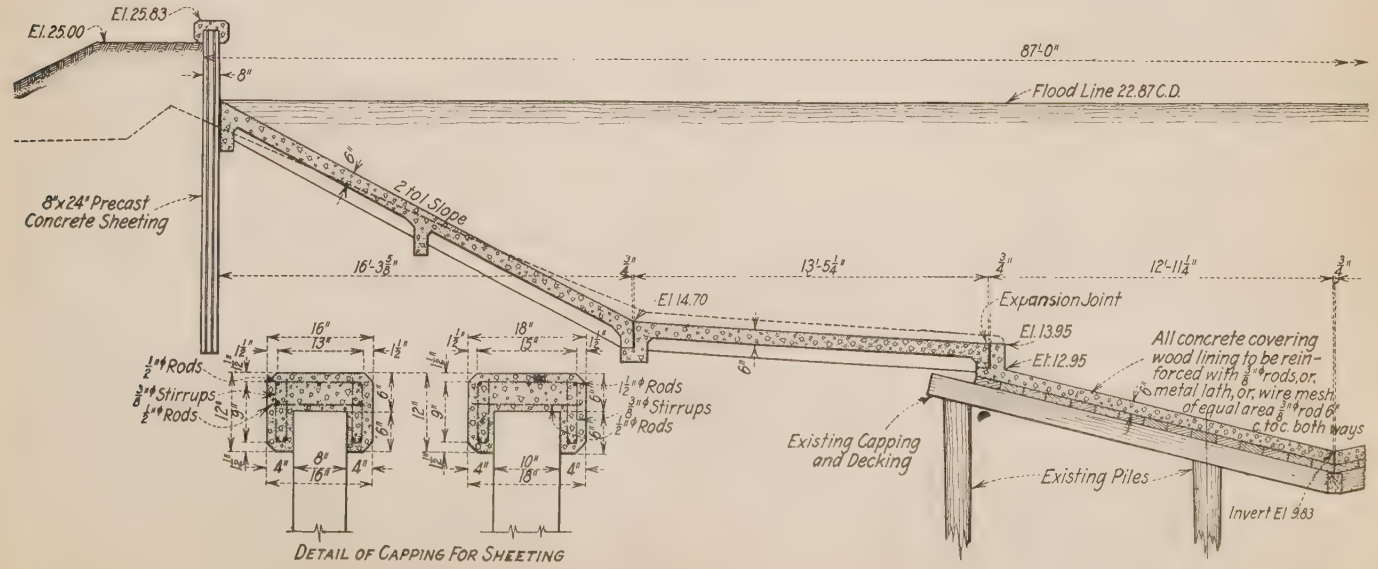
Precast concrete sheet piles form a retaining wall at the outer edges of the concrete lining.

Officials Pacific Northwest Section A. W. W. A.

Due to the fact that Mr. R. F. McLean, who was elected secretary and treasurer of the Pacific Northwest Section of the American Water Works Association, declined to accept the office, the board of directors requested Ernest C. Willard to continue for another year. The corrected list of officers and directors of the section is as follows: Chairman, Alex Lindsay, Superintendent Water Department, Spokane, Wash.; vice-chairman, Carl A. McLain, General Superintendent-Secretary, Eugene Water Board, Eugene, Ore.; secretary-treasurer, Ernest C. Willard, Consulting Engineer, Portland, Ore.; director, Fred J. Sharkey, Superintendent Water Works, Wenatchee, Wash.; director, R. H. Corey, Division Engineer, Public Works Engineering Corporation, Salem, Ore.; national director, W. A. Kunigk, Superintendent Water Department, Tacoma, Wash.

New Orleans Building Three New Incinerators.—Three new incinerators to cost a total of $700,000 are under construction at New Orleans and will add appreciably to that city's sanitation system. This will make a total of five plants where garbage can be readily disposed of. The plants, according to Commissioner of Public Property John Klorer, will be equipped in the most scientific manner with special provision for the prevention of any smoke nuisance.

The incinerators are conveniently distributed about the city, one of the new ones being almost ready for use. The one now nearing completion can handle 170 tons of garbage every 16 hours with no odor escaping, and its stacks are 125 ft. high.



Half of Typical Section Near Pumping Station No. 1, Metairie Relief Canal, New Orleans, La.

Training Operators for Small Filtration Plants

How the Bureau of Sanitary Engineering of North Carolina State Board of Health Has Helped Small Towns Solve the Problem of Securing Efficient Operating Personnel

By J. SUMMIE WHITENER

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The problem of securing and training operating personnel for small purification works confronts almost every small town. Some towns have solved this problem, while the majority are still working on it, and some even have not yet realized that they are faced with it. The excellent methods by which the Bureau of Sanitary Engineering of the North Carolina State Board of Health has helped the small town in that state solve the problem was explained by Prof. Whitener in a paper presented at the St. Louis convention of the American Water Works Association. An abstract of the paper is given herewith.

THE Bureau of Sanitary Engineering of the North Carolina State Board of Health was established in 1919. The first survey of water purification plants in 1921 showed a total of fifty plants, with one plant technically operated, and the necessity for a wholesale reconstruction and improvement program before much improvement in operation could be expected. This program was successfully carried out by using practically the same methods as have been used in obtaining better plant operation and more technical plant operators.

Obtaining Better Plant Operation.—The first step in obtaining better plant operation was the performance of service to municipal officials. Most officials serve for one or two years and in many instances they have no one to advise them as to their responsibilities in matters affecting public health. The bureau's engineers sought to advise them as to the extent of their responsibility, acquaint them with public health laws, and help them solve problems affecting public health. In a great many cases the engineers would roll up their sleeves and help repair equipment that was out of order, giving the plant a thorough cleaning, etc. This helped to convince the officials that these engineers knew what they were talking about and that they were willing to help carry out any suggestions that were made. Such tactics tended to educate and make friends of municipal officials from the mayor on down.

Training Non-Technical Operators.—The methods used in training all non-technical operators, while generally the same, varied in detail for each town and were applied alike to operators newly employed and those who were considered experienced operators. In every case an engineer spent from one to two weeks with the plant operator and instructed him in the proper operation of his plant and in the use of such laboratory equipment as had been provided. The plant was thoroughly cleaned and all equipment overhauled. In some cases this took a great deal of diplomacy on account of antagonism of either the operator or the superintendent, or both, as they looked on the engineer with suspicion, treating him as an inspector to be tolerated and got rid of as quickly as possible. In cases of this kind he spent only a few hours at the plant and, before leaving, called on the city officials and offered the services of the bureau if at any time they were needed. It was then the policy to wait until the town called for help in case of trouble or a sudden emergency. When such a call came an engineer would get on the ground in the shortest possible time, generally in a few hours, and advise the officials what to do and help them do it. He would stay on the job until the trouble was remedied or the emergency had passed. Then he would usually carry out the program of training the operator and cleaning up the plant before leaving. This method often brought better and more lasting results because of the service rendered and the friendly relations established.

In other cases, the operator and the superintendent co-operated with the engineer in carrying out the program of training for the operator. Sometimes the superintendent would take advantage of this opportunity to learn more about plant operation himself, and if the plant needed additional equipment or laboratory apparatus, the superintendent would order it if he had the authority, and if not, the engineer would go with him before his board and back him up in his request. In every case it was very carefully explained to the officials that all parties concerned were handicapped by the fact that a non-technical operator could not take in all that the engineer was able to teach him.

This period of training was followed up from time to time to make sure that the operator understood all that had been taught him and that he had not fallen by the wayside and was neglecting the plant.

Training Inexperienced Technical Plant Operators.—When a technical man was employed by a municipality to operate its purification plant, an engineer was detailed for at least a week to operate this plant and gradually break him in, letting him assume more and more responsibility as he was able. The training of technical plant operators was carried out in the same way as that of non-technical operators, except that it took less time. The engineer was able to explain in detail the theory of water purification and plant design and feel that he was being followed and not wasting his time. The making of laboratory tests and their application to the control of operation was not taught in a mechanical and elementary way, as was done with non-technical men, but the significance and application of every test was explained in detail and understood by the technical operator.

When it was felt that the operator could operate the plant properly, he was left for a week or two and then a few more days were spent with him. During the time the engineer was not on the job the operator knew it advisable to call him back immediately if anything went wrong. In this way the town was not left to the mercy of an inexperienced operator, nor the operator to the mercy of the town. And at no time was the town supplied with unsafe water. This method made lifelong friends of the town officials and the operator, and was well worth the time and money spent.

Educating the Municipalities.—The first contact having been made and friendly relations established on a sound basis, the next step was to explain the necessity of technical plant supervision and that such supervision was not only the best possible insurance against unsafe water but that in almost every case it resulted in a material decrease in the cost of plant operation. As more technical men were employed, this statement was very satisfactorily proved. In some instances technical men saved as much or more than their year's salary in less than a year's time by reducing operating costs. This was done by the proper and frequent adjustment of chemical dosages controlled by laboratory tests, care and maintenance of plant equipment, etc., thereby cutting

down the repair costs and increasing the overall plant efficiency.

Another strong argument was that by employing a technical man who would make daily chemical and bacteriological laboratory tests and keep records of these tests, together with other necessary plant records, the town showed that it was providing the best possible protection for its water consumers against water-borne diseases. Plant records kept by a competent operator have been used in court for the conviction of persons polluting the raw water supply and as evidence to dismiss any suspicions as to the safety of the water supply in case of an epidemic which is later traced to another source.

In small towns it was pointed out that a technical operator with engineering training would be able to serve the town, in addition to his duties as plant operator, in the following ways:

1. As operator in charge of the sewage disposal plant he could make daily laboratory tests and control the plant operation by them. For the average small town sewage plant this would require but very little additional laboratory equipment to that already in the water plant. Records of sewage plant tests and operation are very valuable to the town in case of damage suits brought by property owners on the stream below the plant. With a properly designed sewage plant and technical operation, it is very hard to prove negligence on the part of the town. This helped to change the almost universal opinion that small sewage plants once built needed no operation and could be forgotten.

2. As milk inspector in both large and small towns that have passed the standard milk ordinance, he would be able to inspect the dairies and test the milk delivered in town. This gives the town a competent man to enforce the provisions of the standard milk ordinance. Taken separately, this job would cost the town at least $75 per month, but by combining it with the plant operator's job, it requires an increase of only about $25 a month in his salary, plus travel allowance to and from the dairies.

3. As assistant to the superintendent of water works, city engineer or city manager, he could make accurate maps of the water and sewerage system, keep these maps up to date, and solve many small engineering problems that are always coming up and are not large enough to justify the employment of a consulting engineer. This additional service coupled with the reduction in plant operation costs would more than justify his salary.

4. As superintendent of water works in towns that had enough plant capacity and clear water storage so that the plant could be operated a few hours each day or every other day and supply the demand. The salary for the combined job has in some cases been less than that of a non-technical superintendent.

5. As a final argument, it is pointed out that a non-technical man of the type usually employed as operator, such as garage mechanic, one familiar with steam engines, pumps, etc., would cost the town at least $100.00 per month, but, not having the education and basic training, he could not take in all the bureau's engineers might teach him, and, therefore, could go only so far in the field of plant operation. On the other hand, a technical man can be secured for a salary around $125 and would be able to develop initiative of his own and become of very much greater value to the town.

Locating a Technically Trained Man.—It was quite natural that after having convinced a municipality of its need for a technically trained man the question arose: "Do you know where we can get a good man?" or "Can you get us a good man?" The answer was that not one but several men would be located who could be recommended on the basis of their training and experience and that it would then be up to the town to employ the one that suited them best. When a man is employed an engineer spends whatever time is necessary in teaching him how to operate the plant and check up on his work from time to time to see that the town is getting the type of plant operation it is paying for. If it is found that this is not the case, the engineer will advise the town and recommend that it get another man.

In the first few cases, men with training and experience in plant operation were secured from other states. These men were for the larger towns that could afford to pay them enough to justify a change. The bureau then turned to the list of graduates from the North Carolina State College of Agriculture and Engineering and from the University of North Carolina and found that neither college had a curriculum in sanitary engineering, but that graduates in civil engineering or chemistry could be used and that positions as plant operators were attractive to them. In nearly every case the starting salary was $125 per month. The supply has been kept ahead of the demand between periods of graduation by recruiting men who had started out in other branches of engineering or chemistry, having become dissatisfied and desired to make a change.

Relation of a Plant Operator to Municipality and to Bureau of Engineering.—The operator, as was stated before, is employed and paid by the town. It was explained to him that his recommendation was based on his technical training and on the belief in his ability to do the work. He understands that he is to be helped in every possible way and it is assumed that he will be conscientious and take an interest in his work. He also understands that if he becomes careless or lazy and does not operate the plant properly, he is endangering public health, and drawing a salary which he does not deserve, and that the town will be acquainted with the facts and advised to employ another man.

Monthly Reports.—Monthly report blanks are furnished to both water purification and sewage plant operators. These reports have columns for all necessary plant operation data, cost data and results of chemical and bacteriological laboratory tests. These data are entered on the report daily and at the end of the month the report is totalled and averaged. This report is kept in the plant and two ink copies are made, one for the superintendent of water works or sewage works and one is sent to the bureau of sanitary engineering at Raleigh. When these reports reach the bureau's office, they are carefully checked for mistakes in calculation, poor plant efficiency, or improper operation. Such errors are called to the operator's attention by letter or by a visit from one of the engineers.

Field Inspections.—Routine inspections are now made of each plant once a month. The number of inspections made of any one plant varies according to the number of engineers available and to the character of the plant operation. In making an inspection, if the engineer finds anything wrong he calls it to the attention of the plant operator and discusses with him the best method of correcting the trouble. In case additional equipment is needed, he goes with the operator to the superintendent and backs up the operator's request. If necessary, an official letter to the town board is written recommending the additional equipment. In this way the operator feels that an inspection of his plant is made not for the purpose of criticising his operation but to make suggestions that might improve the operation and help him solve any problems that have been troubling him. This method, besides giving a true picture of the operation of each plant, keeps the engineers on very friendly terms with the operators and superintendents and promotes the best kind of cooperation.

Investigation and Research.—In case serious trouble is reported by an operator, an engineer is detailed to spend whatever time is necessary for investigation and research, to locate the source of trouble and to help the operator work out some method of correcting it. Recently the manufacturers in a small town complained to the bureau about the excessive scale formed in boilers using water from the town purification plant. This plant did not have a technically trained operator and the town officials had been perfectly satisfied until they were rudely awakened by the manufacturers. Just at this time the plant operator was acci-

dentally killed and the town called for assistance. An engineer was sent to operate the plant and to locate the cause of the boiler scale. It was found that the scale was caused by improper adjustment of chemical dosages at the plant and a recommendation for the employment of a technical operator was acted on at once. By operating this town's plant for two weeks the manufacturers were given relief from excessive boiler scale and convinced of the fact that they needed a technical operator.

Advancement to Better Positions.—In the case just mentioned, the technical operator had been running a plant in a smaller town for about four months at a salary of $125 per month. Prior to that he had been in a city engineer's office making $150 per month, but saw no chance for advancement and decided to change to sanitary engineering. The second town paid him $150 per month, so in four months he had changed from one branch of engineering to another and was receiving the same salary. Since then he has accepted the position as plant operator in a larger town and is in line for the position of superintendent of water works. This is a typical case and is used as a very good argument in getting technical men to accept positions as plant operators.

Advancement in any case depends on the ability, initiative and conscientiousness of a plant operator. When an opening occurs in one of the larger plants, an operator with experience at a smaller plant is usually given the position and in some cases three or four men are advanced to better jobs with more salary, and an inexperienced technical man is started in on the smallest plant.

Before recommending an operator already employed by one town to another town, the officials in the first town are always consulted and advised of the proposed recommendation of their operator for employment by another town. If the operator is receiving the maximum salary the town is able to pay and the second town is willing to pay more, the change is generally made, and the first town employs another operator with less experience at a smaller salary. If the operator is not receiving the maximum, his salary is frequently raised by the first town in order to keep him. Operators have often had their salaries increased without knowing until afterward that a recommendation had been contemplated. The bureau in all cases is governed by what is fair to both the town and its operator and all parties concerned have realized that it was interested in securing the best possible plant operation for every town in the cause of public health.

The bureau has had a great deal of trouble in keeping the personnel of its own organization because the larger towns, realizing the type of training its engineers receive, are willing to pay them more as plant operators than they receive as engineers. It has lost one man to another state because that state doubled his salary, another to the North Carolina State College and one to the University of North Carolina. Both institutions now have courses in sanitary engineering, and the two men became professors of sanitary engineering at these colleges. When a man leaves the organization to go with a town or a college the bureau does not consider that it has lost a man, but rather that another good technically trained operator or college professor has been released who knows its policy and will help the state improve its public health.

Value of the North Carolina Section A. W. W. A.—The North Carolina section of the American Water Works Association has been the largest contributing factor in securing and maintaining technical supervision of water purification and sewage disposal plants. A majority of the members are water works superintendents and plant operators. Those superintendents and operators who are not members know that they are welcome to attend all meetings. That they do attend is proved by the fact that the number attending is always much larger than the membership.

A separate conference of water purification plant operators was formerly held at the same time as the section meeting. Separate sessions were held because some of the older superintendents did not care to listen to long, detailed, technical discussions of filter plant problems. In 1928 the section voted to abolish this conference and to have all papers included in the regular section programs, because it was found that the attendance at these conferences was greater than at the regular section sessions. This was due to the increased number of technically trained superintendents and operators and to the changed viewpoint of the non-technical superintendents and operators.

Results.—The training of technical and non-technical plant operators has caused a general increase in plant efficiency and a general decrease in the total cost of filtration. Their better understanding of plant operation has helped increase the factor of safety against water-borne diseases. By the proper control of filtration with laboratory tests, plant effluents with a B. Coli index of zero are becoming common. Secondary lime treatment for red water control has become standard practice and prechlorination is being used in a number of plants to good advantage.

In one instance a technical operator worked out a treatment process for highly colored water. This process consisted of a primary dosage of chlorinated copperas and a secondary dosage of either sodium aluminate, or alum and lime added simultaneously. Another technical operator increased the length of filter runs, lowered the cost of operation and turned out a better effluent, by the chlorination of coagulated water.

Of the 78 municipal water purification plants in the state, 63 are in small towns and 28 of these plants are operated by technical men. Twelve of the 15 plants in large towns are technically operated. Three out of five institutional plants are operated by technical men. One town with a population of 1,147 has a technical operator who serves as superintendent of water works, looks after the sewer system, and operates the disposal plant.

Sewage plants are better operated because more of them are under the supervision of the water plant operator. More complete and accurate reports of the operation of both water and sewage plants are being kept. These reports are valuable to the individual towns and when compiled into yearly state reports by the bureau they become of even more value to the state as a whole.

The municipalities have been educated to the point where they realize the value of technically trained men as operators. This realization of their value has increased the demand for technical operators. Because it was found that graduates in civil engineering or chemistry were not properly fitted for sanitary engineering work, State College and the University have added sanitary engineering to their courses of instruction. State College now has a 4-year course in sanitary engineering and courses for graduate students.

This course is designed to prepare graduates for positions as technical operators to supply the demands of the municipalities.

Co-operation between the administrative agencies and educational institutions of the state has materially aided the rapid progress made in sanitary engineering and public health work. Such co-operation must be practiced in any state that expects to make much progress.

Town Has 7-Year Water Service Contract.—All applications for water service from the town of Monson, Mass., are now asked to contract to pay the regular water rent of $6 a year for seven consecutive years, whether they use the water or not, and the contract extends to their heirs and assigns. This rule has been adopted by the water commissioners in order to prevent any future misunderstandings. This covers the cost of tapping the main and conveying the water to the patrons' premises.

Chlorinated-Copper as a Coagulant

Recent Developments in Its Use at the Chickasaw, Ala., Filtration Plant

By A. CLINTON DECKER

Sanitary Engineer, Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., and Chickasaw Utilities Co., Mobile, Ala.

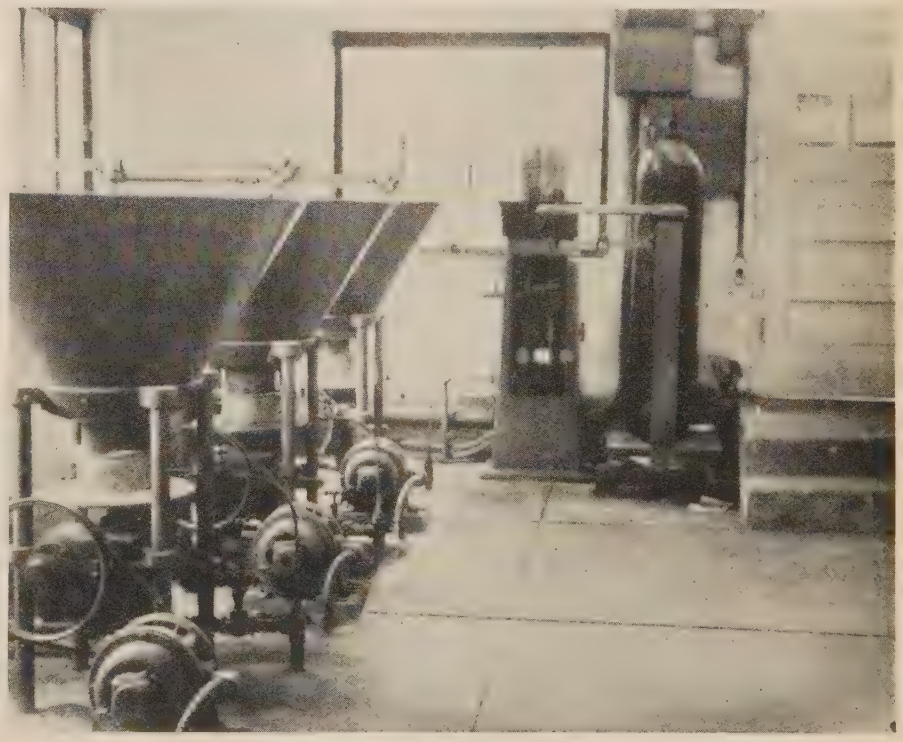
EARLY in 1929, a series of experiments were undertaken by Mr. H. G. Menks, Assistant Sanitary Engineer, Alabama State Board of Health, and the writer at the Chickasaw, Ala., filtration plant. This plant is owned by the Chickasaw Utilities Co., a subsidiary of the United States Steel Corporation and was leased early in 1928 to the Alabama Water Service Co. to supply the towns of Chickasaw and Prichard and contiguous territory.

The Supply.—The source of supply for this plant is Eight Mile Creek. This stream originates in springs and flows through a heavily cypress wooded territory which imparts to the water a color normally ranging from 40 to 130 p.p.m. The alkalinity ranges from 2 to 5 p.p.m. and constitutes the total hardness. The turbidity is normally very low, ranging from 3 to 25 and on very rare occasions being as high as 50. The pH varies from 5.5 to 5.9. The bacterial content is normally under 100 per c.c. at 37½° C. Color removal constitutes the most difficult problem in connection with the treatment of this water. The first experiments which were made included the use of ferrous sulphate, alum, lime, and soda ash in various quantities and combinations. It was our opinion that the best results of coagulation and color removal were obtained when 3 grains per gallon of lime and 5½ grains per gallon of alum were used. The filtered water showed an alkalinity of 8, color 0, turbidity 0, and pH 6.4.

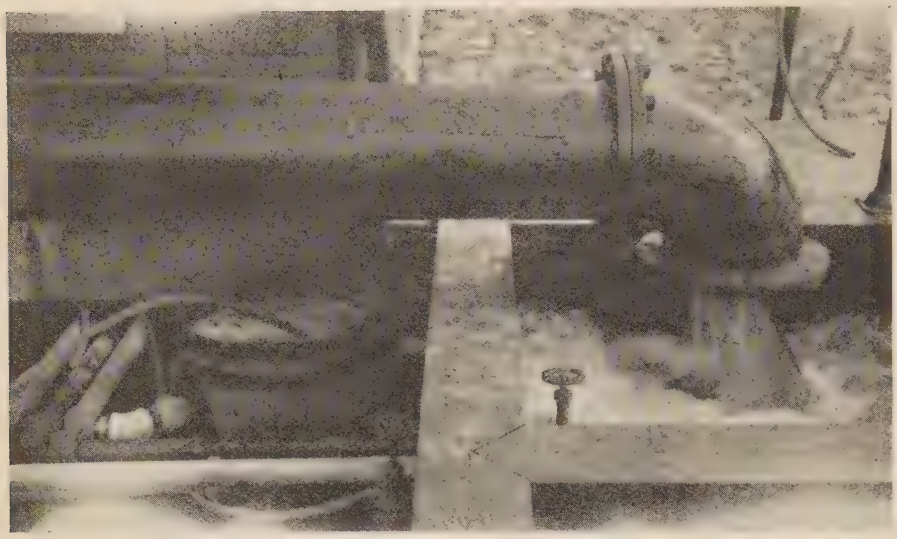
Experimental Work.—On the basis of these results, it was concluded that a treatment plant could be operated to produce desired results, and plans were prepared in accordance with recommendations made as a result of these experiments. After the plant had been designed and construction started, the possibility of the use of "chlorinated-copperas" was brought to our attention by Mr. L. H. Enslow, Research Engineer of the Chlorine Institute. Experimental work was then undertaken with this coagulant and further work done with coagulants previously used. It was found that best results were secured by using 0.7 of a grain per gallon of copperas oxidized by adding, in addition to the theoretically required amount of chlorine to oxidize the ferrous iron (1.5 p.p.m.), an additional amount sufficient to satisfy the chlorine demand of the raw water, making a total of 2.16 p.p.m. of chlorine applied to the copperas solution. There remained at the end of the mixing chamber 0.2 p.p.m. of residual chlorine. There had thus been produced simultaneously, copperas oxidation and prechlorination. In passing through the coagulating basins, the residual chlorine disappeared and water passing on to the filters showed no trace of chlorine. Although good coagulation was obtained with much smaller doses of "chlorinated-copperas" than 0.7 of a grain per gallon, the color removal was not complete except when the above amount was used.

Coagulating Basins and Filter Building

"Chlorinated-copperas" is prepared by mixing a solution of ferrous sulphate ($FeSO_4{:}7H_2O$), commonly known as "copperas" and chlorine water from a chlorinator. The copperas may be fed



The Chemical Feed Machines



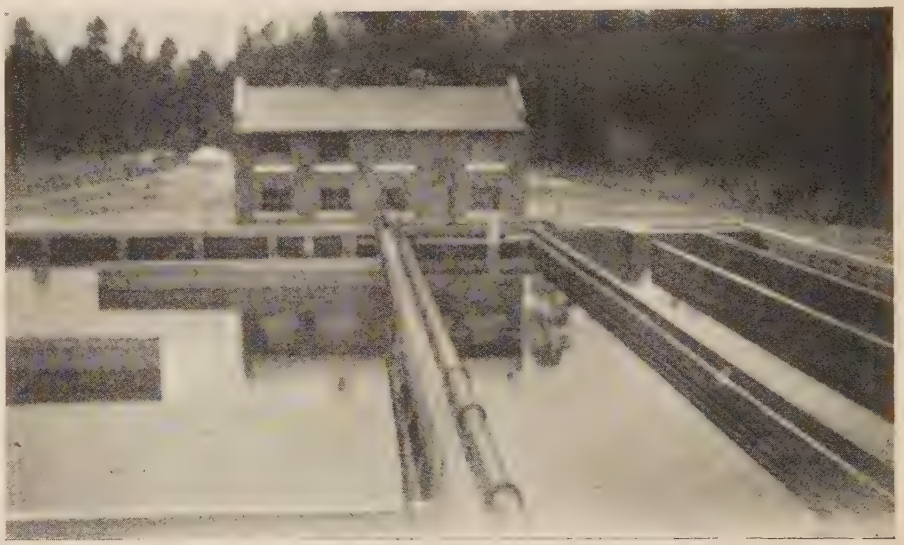
Barrel in Which Copperas Is Chlorinated

would be used, the equipment selected was Wallace and Tiernan Type "B" dry feed machines and Type "M.S.V." chlorinator. The mixing device used consisted of a 50-gal. barrel which was placed on a bracket immediately adjacent to the first compartment of the mixing chamber. The copperas solution line from the dry feed machine was so arranged as to lead into this barrel and discharge at a point near the bottom, causing a swirling action in the barrel. The chlorine was introduced through the chlorine discharge hose at a point near the bottom of the barrel. The "chlorinated-copperas" was discharged from an outlet pipe located near the top of the barrel into the mixing chamber.

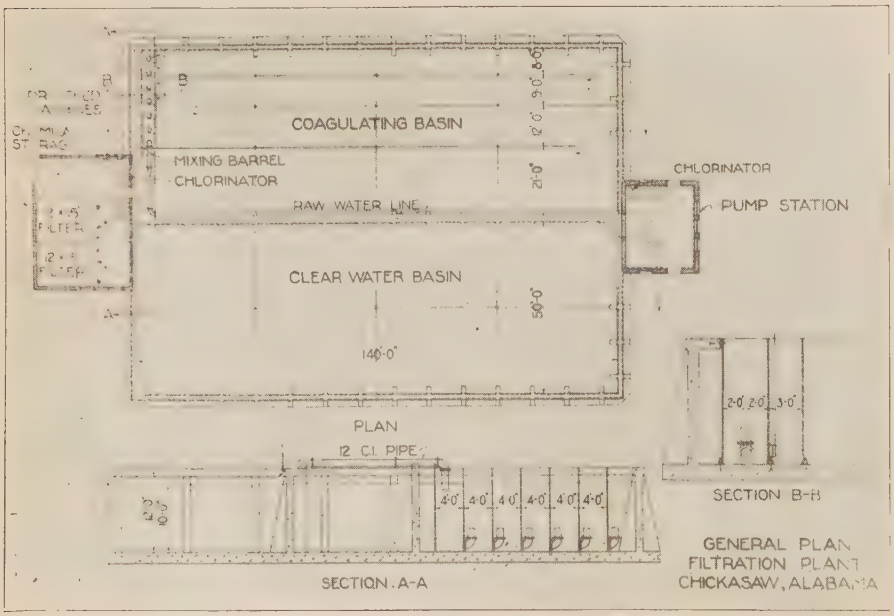
The filtered water showed a pH of 5.9 to 6.1. It was therefore necessary to adjust this value, by the use of lime, to approximately 7.0 to 7.2. It was noted that when the pH was adjusted to 7.4, the appearance of the water was slightly impaired. The alkalinity of the finally treated water was 7 or 8 p.p.m In the design of the plant, provision had been made for introducing lime at various points in the last bay of the coagulating basin. During the experimental operation of the plant, the lime was introduced into the clear water well immediately adjacent to the filter effluent pipes, and into the last bay of the coagulating basin approximately 50 ft. from the filters and 130 ft. from the filters. The final quality of the water was not as satisfactory when lime was introduced into the coagulating basin as that obtained when the lime was introduced into the clear water well. Although there was a very slight increase in the color when lime was introduced into the clear water well, this increase was not as great as when the lime was introduced into the coagulating basin. At times, since the plant was placed in operation, suffi-

from a dry feed machine or mixed into solution in a tank and fed through orifice boxes. As the function of the chlorine is to oxidize the ferrous iron before it reaches the raw water, it is essential that extreme care be exercised in designing apparatus which will secure this result continuously. Complete oxidation of the ferrous iron is essential and therefore frequent tests should be made during the operation of the plant to determine that this result is being obtained. It cannot be emphasized too strongly that it is far preferable to operate on the side of safety and always have present an excess of chlorine rather than to, at any time, introduce into the coagulating basin a solution which has not been completely oxidized.

Application of Chlorinated-Copperas.—When it had been definitely determined that "chlorinated-copperas"



Coagulating Basin, Clear Well and Filter Building



General Plan of Filtration Plant of Chickasaw Utilities Co. at Chickasaw, Ala.

cient lime to increase the pH to 8.0 has been used without seriously increasing the color. The coagulating basin is divided into four bays by three round-the-end baffles. These baffles are so set as to produce theoretical velocities varying from 1.165 ft. per minute in the first bay to 0.445 ft. per minute in the fourth bay. This arrangement effects a more even distribution of the sludge. However, the greatest volume of sludge is precipitated in the first bay.

Advantages.—Compared to other processes of coagulation, it was found that this process was efficient and economical, while introducing no difficult problems in operation. The saving in cost of chemicals, as compared with that of other processes tried, was found to be approximately $10 per million gallons. A further economy resulting from the use of "chlorinated-copperas," as compared to alum and lime, is the increased length of filter runs which is sufficient to effect a saving of 50 per cent or more in wash water required.

Experimental work done recently by Mr. John R. Baylis on Lake Michigan water at Chicago has indicated that "chlorinated-copperas" and aluminum sulphate were required in ratios varying from 3 to 5 in winter when the water was cold to 1 to 3 in summer when the water was warm; that is, "chlorinated-copperas" was about three times as effective as aluminum sulphate. Baylis also points out that in addition to being cheaper, another advantage of ferric salts over aluminum sulphate in many waters is the wide pH range over which precipitation may take place.

These advantages indicate that "chlorinated-copperas" will, in the future, be used more extensively in order to combine economy, efficiency, ease of operation, and flexibility in the matter of securing coagulation over a wide pH range.

Acknowledgment.—The foregoing is an abstract of a paper read before the Southeastern Section of the American Water Works Associaton at the annual meeting, held at Savannah, Ga., April 15, 16 and 17, 1930.

Prominent Engineers of the World Receive Medals

Sixteen of the foremost engineers of the world from as many countries described the influence of engineering upon the life of the people in their parts of the world as a part of the 50th Anniversary Celebration of the American Society of Mechanical Engineers.

The papers also visualized the future of engineering in the promotion of the welfare of the people. The authors were awarded the Fiftieth Anniversary Medal by ambassadors of their respective nations, resident in Washington.

Julio Kilenyi, portrait sculptor, is the designer of the medal. He has designed many medals, including the John J. Pershing medallion, the President Coolidge inaugural medal, the Charles A. Lindberg medal and the Thomas A. Edison medal for Edison Pioneers. This recent creation symbolizes the engineer and his past and present achievements.

The United States was represented among the sixteen by Dr. C. E. Grunsky, president of the American Engineering Council, and Great Britain by Loughman St. L. Penred, editor of "The Engineer." Other countries and their representatives were: Canada, Brigadier General C. H. Mitchell, dean of the faculty of applied science of the University of Toronto; Germany, Dr. Ing. Conrad Matschoss; France, Georges Claude; Japan, Dr. Masawo Kamo, of the Tokyo Imperial University; and Italy, Senator Luigi Luiggi.

South America's representatives were Prof. Donato Gaminara, of Uruguay, a member of the Pan-American highway commission, and Prof. Julio Garzon Nieto, a chief engineer with the Colombian government. From Austria, Hofrat Ing. L. Erhard, director of Technisches Museum, Vienna, came; from Belgium, Monsieur le Baron Gaston de Bethune, representing six eminent engineers; from Netherlands, Prof Ir. D. Dresden; from Scandinavia, Vilhelm Nordstrom, of Stockholm, Sweden; and from Switzerland, Prof. Dr. Aurel Stodola, a professor at the federal technical high school in Zurich. Mexico also was represented.

Power from Volcanic Steam

In Larderello, a region near Pisa, in Italy, volcanic steam springs up from crevices in the ground. If steel pipes, some 10 in. in diameter, are sunk from 150 to 200 ft. into the ground, steam at 5 to 6 lb. atmospheric pressure spurts up, and if properly collected by other steam pipes and reservoirs, a regular supply can be utilized for driving steam engines. The first experiments were made about 1916-17 with a 50-hp. steam engine. It worked perfectly for months. Then the idea of making a real serious industrial experiment was realized in a plant of three 5,000-hp. steam turbines, connected with three dynamos. The experiment was most successful and has been working regularly up to now. The electrical energy is distributed to the small cities in Tuscany for illumination. Thus even volcanic steam is being employed to solve the lack of fuel problem in Italy.

Reforestation by Hackensack Water Co.

Experimental reforestation started twelve years ago by Robert W. De Forest, in Bergen County, New Jersey, is developing forested areas as an instrument of sanitary control. In the uplands surrounding Oradell Lake, one of the storage reservoirs of the Hackensack Water Co., of which Mr. De Forest was then president, and of which he is now chairman of the board, pine groves are rapidly taking shape to afford protection from contamination and erosion.

Many acres of splendid pines are flourishing in Haworth, Harrington Park, and Emerson. Mr. De Forest's reforestation policy is being continued under his successor, Nicholas S. Hill, Jr., of New York, who announces that in the Spring further experimental planting will be carried out in the area created by dredging the Hackensack River and its tributaries at the north end of Oradell Lake for water purification and operation purposes.

This area, traversed by some highways carrying heavy motor traffic, is more than five miles long and about half a mile wide. It comprises large expanses of water and long flat winding islands.

In co-operation with the Mosquito Commission, the water company is assuming control of drainage problems and is thus improving sanitary conditions in the areas tributary to the Hackensack River.

Weeping willows, elms, and sweet gums will be planted in the low spots which are no longer swampy. On higher ground, masses of white birch will be set out, while near roads, there will be plantings of red, white and Scotch pines from the Water Company nurseries.

Oradell Lake is one of the largest artificially dredged reservoirs in the country, and in its construction several million cubic yards of excavated material was deposited in wide areas surrounding the shore line. Much of this material was pure sand and seemingly unsuitable to the growth of trees. Yet certain varieties of pines literally thrive in such surroundings. The reason is that this excavated sand contains a great deal of humus, and presents a surface that acts as a mulch to conserve the moisture below, George R. Spalding, sanitary engineer of the company, explains.

Numerous kinds of pine trees, each adapted to the character of the soil, are utilized in the various plantings fostered by Mr. De Forest in the belief that all of the territory immediately adjacent to the reservoir should be both protected and adorned. These pines consist principally of long lived varities such as Norwegian Red Pine and native American Pine, which keep their beauty and attain great age and size.

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Active Water Taps as Indexes of Population

The number of active taps, or of meters where universal meterage exists, is the best index of city population in America. Each city, however, has its own ratio of population to taps, but as this ratio changes very slowly, and in a way that can usually be estimated quite accurately, it becomes possible to determine its population with great accuracy.

We suggest to the heads of all water departments and companies that the ratio of population to active taps be calculated now and compared with the corresponding ratio 10 years ago, and that the rate at which that ratio has changed be determined. Then, guided by these data, an accurate estimate of population can be made each year until the next census 10 years hence. The resulting calculations should be published in the annual reports, for it is often difficult to ascertain what was the number of active taps at a given time in the past.

In a town where many of the inhabitants still secure their water from wells, a count should be made of the wells, once a year, so that allowance can be made for any increase in active taps that does not result in an increase in population.

The total number of taps is a less significant figure than the number of active taps, especially in a town that is not growing rapidly, for obviously an unused tap is not a measure of population. Of course, where the number of idle service pipes is a constant percentage of the total number, no error would result from estimating the population on the basis of the total number.

Chambers of Commerce are accustomed to estimate city populations in several ways. The number of school children, the number of registered voters, the number of telephone users, the number of names in city directories, and some other indexes of population are commonly used. The birth rate is declining, while the number of years that the average child remains in school is increasing, hence school registration is not a very reliable criterion of population. Registered voters are notoriously unreliable. City directories have all but vanished since most of the residents of cities have become telephone users whose addresses can be found in telephone directories.

In passing, we may add that the telephone companies are usually better informed as to the population of each city than is the Chamber of Commerce or any other private corporation or association. Of all the public sources of information as to population, none is equal to the water department of a city in its ability to give an accurate estimate of population. If, then, the water department would cooperate with the telephone company, by comparing their population estimates once a year, no serious error would ever creep into the estimates of population.

Cries of dismay have recently arisen from hundreds of Chambers of Commerce over the populations disclosed by the census. Many recounts have been demanded, and all because unreliable criteria of population have been used by Chambers of Commerce.

At no great expense the U. S. Census could be kept up to date for every city and town in America by adopting the method above outlined, and there would then be no disappointments when the results of the decennial census count were published. Moreover, city engineers, water superintendents and other who plan water works and sewerage systems and extensions would always have reliable population data upon which to base their plans not only for each city as a whole but for each section of the city.

The telephone engineers design underground conduits to take care of population growth at least 10 years ahead. To do this with accuracy they must know the rate of growth of each section of the city. It is not sufficient to know that the growth of the city as a whole is, say, 20 per cent in 10 years. They must know its rate of growth in its different sections; for if one section is growing at the rate of 30 per cent, while another is growing at the rate of 5 per cent per decade, much larger conduits should be be built in the one than in the other section to provide for future population. The same holds true of water mains and sewers. Hence it is not merely a matter of curiosity, but a matter of economy, that prompts the keeping of accurate records of population growth in every part of every city.

The Alleged Profiteering of Electric Companies

With the periodicity of a sunspot cycle comes the discovery that electricty retails at 10 to 15 times its generating cost. The discoverer is usually a politician who immediately broadcasts his discovery, at the same time charging the power companies with profiteering. If such charges were true it would follow that all public service commissions are either derelict in their duty or are in collusion with the power companies.

The fact is that the main cost of electricity sold at retail is the cost of transporting it. In that respect it resembles sand or gravel which cost, say, 10 ct. a cubic yard loaded in the truck and $1 delivered to the builder of a house several miles away from the pit. A more closely analogous case is the cost of water pumped from a lake and delivered through pipes to domestic consumers. The cost of pumping the water is, say, 1 ct. per 1,000 gal., but the entire cost of the delivered water is, say, 10 ct. per 1,000 gal., including interest, depreciation and operating expenses.

An electric generator is really a pump, and it pumps electrons along the conducting wires. The electrons flow through the wires, like water through a pipe, and

their energy is put to use by the retail purchaser of the "juice." He pays, let us say, 8 ct. per kilowatt-hour for the current. This is equivalent to 6 ct. per horsepower-hour. Hence he buys the service of a powerful horse at the rate of 48 ct. for an 8-hour day. A horsepower is fully 8 man-power, hence he buys the equivalent of the services of a very muscular man for 6 ct. a day. It is as if he were hiring a strong man to do household or farm work at 6 ct. a day. Since he could not ordinarily hire a flesh and blood man in America for less than $3 a day, the services of this electrical equivalent of a man-power cost one-fiftieth as much.

Yet there are not a few politicians who try to stir up public animosity against the electric power companies that have made this amazingly cheap power available to more than three-fourths of the families in America. Such politicians completely ignore the fact that electric power has practically eliminated "the servant problem" in American homes.

All the heavy household work, from washing to sweeping, can now be done, and usually is done, by machines driven by electricity. Sewing machines, vacuum cleaners, clothes wringers, refrigerators, fans, radios, and many other devices are run by the electrons that are on tap at any moment of the day or night, and always ready to work at a wage of less than a cent an hour per man-power.

No country in the world uses as much electric power as America uses. None can match us in the variety of domestic and industrial uses that we have devised for electricity. The municipally owned electric plants of Great Britain lag far behind American power plants in per capita sales of "juice." Yet an intelligent man like Ambassador Frederic M. Sackett sees injustice in charging 15 times as much for current at the consumer's premises as it costs to generate it many miles away. Fixed charges on transmission lines, distribution lines, transformers, services, meters, meter-reading, accounting, billing and all other office expenses incurred in selling a mere dab of electricity to each domestic consumer, mean nothing to such a critic, for he knows next to nothing about them.

Einstein Space

In recent lectures Einstein has indicated his belief that "space" is primary and that all else is secondary. Space will have to be regarded as primary and matter derived from it as a secondary result. * * * Space has swallowed up the ether and time, and is about to swallow up the field and corpuscular theory too, so that space will remain as the only theory representing reality. * * * Space is changeable and can be influenced. It is analogous in structure to the electromagnetic field." And he goes on to add that time and space could not be known were there no bodies, which is undoubtedly true but apparently not in accord with his statement that space is the only reality.

Since we have no means of measuring dimensions save by the aid of matter, and since dimension is an essential spatial attribute, well may it be asked how space can "swallow up matter," as Einstein puts it.

It seems to us that Einstein has adopted the essential qualities of ether and has rechristened the aggregate space. Ether was conceived by Faraday and Maxwell as a material that conveys radiant energy and serves as a "field" for the operation of electric and magnetic forces. Einstein's space is made to serve these same functions, but he strives to divest it of materiality, while at the same time stating that it possesses the basic attributes of matter, namely energy, inertia and gravitative power. As between Maxwell's conception of ether and Einstein's conception of space, the former enjoys the distinct advantage of having led to many important discoveries. Not one of Einstein's discoveries has sprung from any thing new in his theory of space. His entire theory of relativity is just as tenable under Maxwell's ether theory as under Einstein's space theory. Indeed two of Einstein's three basic formulas were first deduced by Lorentz, who used an electrodynamic theory, namely the formulas for relative length and relative time. Einstein went a step farther and deduced a formula that shows the convertibility of mass and energy—a truly marvelous deduction, but one not in the slightest degree dependent upon his peculiar theory of space.

In so far as Einstein's theory of space is comprehensible, it bears a striking resemblance to the ether theory. In both theories it is recognized that radiant energy exists in regions apparently not occupied by ordinary matter. This radiant energy, however, has two fundamental properties of matter. It has inertia and it gravitates. The proponents of the ether theory urge that since radiant energy in space discloses those two fundamental properties of matter, some sort of thing like matter occupies all space, and they call it ether. The Einsteinists insist that radiant energy may exist in the absence of anything like matter, and they designate the medium or field where radiant energy exists as space.

At bottom, then, the question is whether radiant waves can exist where there is no matter to wave. The ether advocates insist that they can not conceive a wave where no substance exists. The Einsteinists insist that it is of no consequence whether that can be conceived or not; and that it is simpler to regard radiant waves as existing in a space that has no materiality whatsoever. We confess to a strong preference for the ether theory. Moreover we believe that a logic that abandons conception, or "mental picturing," as a criterion of possible truth is unsound. Certainly all scientific progress thus far has resulted from mental picturing, usually based on analogy. Even Einstein's theory of space is one in which space is regarded as like matter; and only in so far as that analogy has been used by him has he made any discoveries. Einstein's space teems with energy, and every unit in which he measures that energy is a material unit. His "clocks," his "yard sticks" and his "scales," by which he times, measures and weighs, are all material things. Let it be granted that the ticking of clocks varies, that yardsticks change their length, and that scales weigh differently, depending upon their relative velocity. What of it? We have simply learned that no unit of matter is independent of other units, and that all are parts of a vast complex that pervades the universe. And this is true whether that all-pervading complex be called ether or space.

Thus far no discovery has been made by denying that this all-pervading thing is a material thing, whereas almost the entire science of radiant energy has been developed by men who were guided by the ether theory. It will take a deal of discovery based on Einstein's peculiar space to warrant scientists in proclaiming that king ether is dead—long live king space.

F. P. Gillette

Cold Weather Troubles in Filtration

Experiences at the Water Purification Plant of Lawrence, Kan., in the Application of Chlorine and Lime at Low Temperatures

By C. T. HOUGH

Water Superintendent, Lawrence, Kan.

CLOSE observation in the operation of a water purification plant continually presents new problems to the water superintendent. Many times these problems are never overcome without considerable cost, and at times no solution seems possible.

General Details of Supply.—The city of Lawrence obtains its water supply from the Kaw River. The treatment includes plain settling, coagulation, softening, chlorination and filtration. During the year the alkalinity of the raw water varies from 125 p.p.m. in the summer season to 300 p.p.m. in winter. The sulphate hardness is 60 p.p.m. to 125 p.p.m. during these seasons respectively. It is therefore apparent that with a maximum total hardness of 425 p.p.m. a considerable amount of lime must be used to bring about a reduction of some 200 p.p.m. during the winter season.

At low temperatures the reaction of lime in cold water is slow, and this slow reaction produces an effect of reduced retention period in the basins. A large quantity of the precipitated calcium carbonates are unable to settle out and are carried over onto the roughing filters which receive the lime basin effluent. A dosage of 0.7 gr. per gallon of aluminum sulphate is therefore applied to the lime basin influent to assist in settling this precipitate and decrease the roughing filter load. Even though aluminum sulphate is applied, the settling is not complete and a large amount of wash water is required to keep the roughing filters in good condition.

Softening Treatment in Cold Weather.—During the past two years an attempt has been made to maintain the total hardness of the treated water below 125 p.p.m. This is easily possible during the summer months, but during the winter the extent of softening treatment depends upon the amount of normal carbonates in the filter influent. From best authority we know that the normal carbonates in the water should not exceed 16 to 20 p.p.m. for proper filter operation. During the summer months the alkalinity may be carried as low as 40 p.p.m. with normal carbonates at 16 p.p.m. During the winter months the alkalinity cannot be carried below 80 p.p.m. An attempt to carry the alkalinity to 50 p.p.m. at various times during low temperatures has resulted in excessive high normal carbonates and a heavy precipitate on the final filters. An analysis of this precipitate or filter sludge shows that nearly 50 per cent of the sample contained aluminum hydroxide, the remainder consisting of calcium and magnesium carbonates. This precipitate is therefore probably due to the retarded reaction of the aluminum sulphate in the presence of a highly lime treated water. The reduction of the lime treatment, thereby increasing the alkalinity to 70-80 p.p.m. eliminates a large percentage of the precipitates and permits satisfactory filter operation.

Increasing Contact Period for Chlorination.—In September, 1926, a bacteriological laboratory was installed at the plant and daily routine analysis begun. In December of that year these daily analyses of the treated water began to show positive tests of the coli-aerogenes group. The chlorine dosage was increased daily, but without favorable results. It was soon learned that this condition had occurred in the past and various attempts had been made to overcome the trouble. Up to this time the chlorine had been applied to the clear well effluent as the piping was not arranged for chlorination of the effluent from the filters. The chlorine treatment appeared to have no effect irrespective of the quantity applied and it was at once apparent that here was another "cold weather trouble." Samples were taken every four blocks along one main feeder to the city and these samples analyzed. It was found that all samples were positive along the first 1½ miles from the plant, and beyond this point they were negative. These results indicated that the reaction of chlorine in water having a temperature of 38 to 40° F. was slow, and that the chlorine must have a sufficient contact period before the water is pumped to the city. An additional chlorinator was immediately procured, and a chlorine dosage first applied at the filter influent. The results were better, but the trouble still existed. The chlorine dosage was then applied at the lime basin influent, allowing more retention period and the bacterial tests at once showed negative results. With the double chlorination method, the total quantity of chlorine applied was not increased. About 2½ lb. of chlorine per 1,000,000 gal. was applied at the lime basin influent and 2 lb. to the suction of the high service pumps. It is believed that very little benefit is obtained from the second chlorine dosage, however this second dosage is added for additional protection.

Further operation with double chlorination has proven that the effect of chlorine in cold water not only depends upon a sufficient contact period, but that the pH value, or the extent to which the softening process is carried also depends upon the bacterial quality. During the past three months softening has not been carried to such an extent as in former years. The alkalinity of the treated water has been maintained between the limits of 100 to 150 p.p.m. The temperature of the treated water at the plant during this time has been 37 to 40° F. Daily bacterial analyses have brought continual negative results. Recent attempts to increase the lime dosage to give an alkalinity of 60 to 70 p.p.m. caused positive bacterial tests immediately. This condition was no different than in past years and was accompanied with the usual increased precipitate on the filters. These positive results however do not remain permanent. Samples taken along the main feeder lines some distance from the plant have had sufficient time for the chlorine to react, and analyses of samples taken on the tap daily at the State Board of Health laboratories are negative. It is evident therefor that increasing the pH value of the treated water decreases the effectiveness of chlorine.

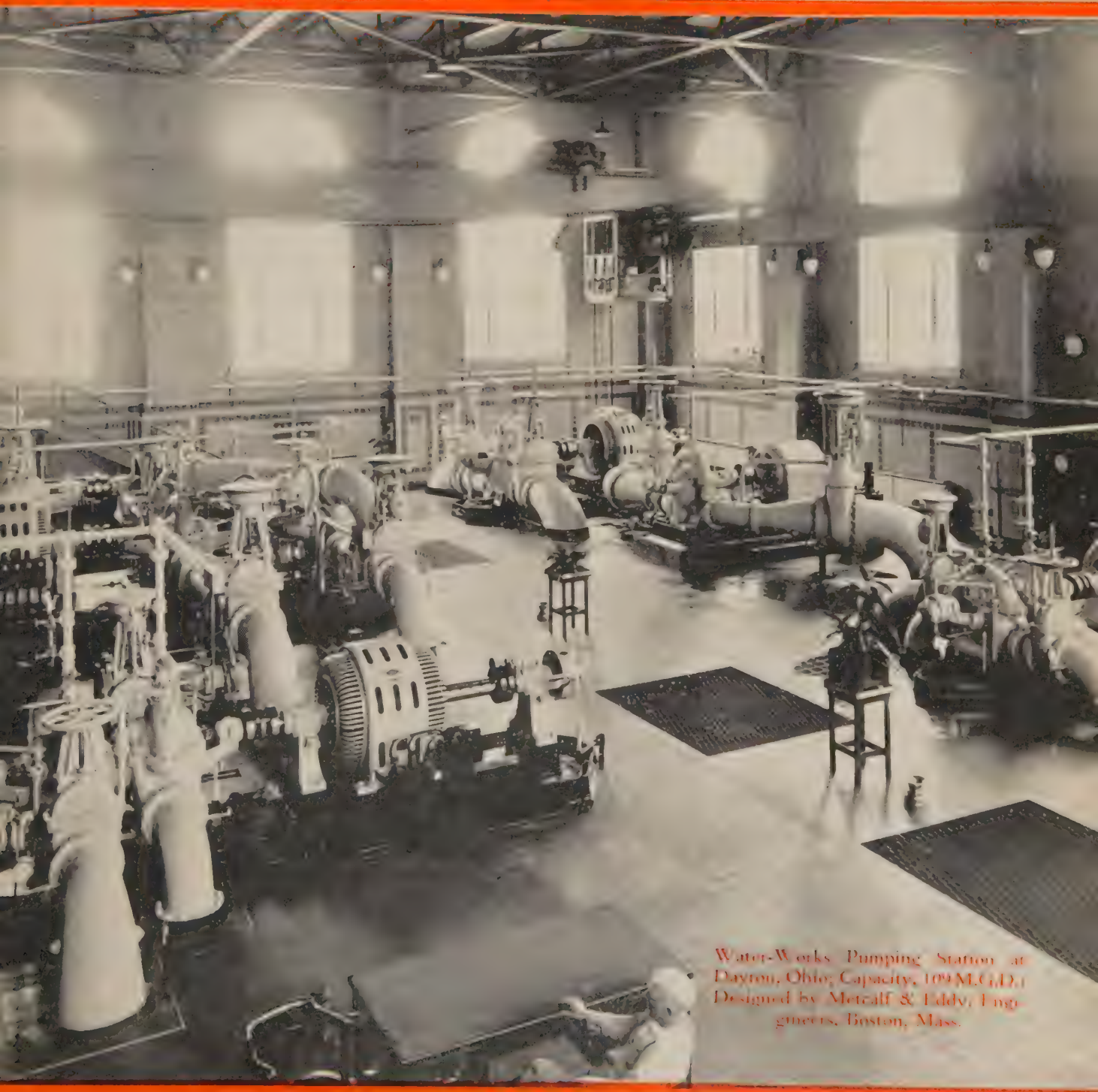
In conclusion it may be stated that no attempts have been made to conduct a series of tests on these conditions through the usual plant operation, for we do not wish to jeopardize the rating of the bacterial quality of the water either with the consumer or the State Board of Health. From this experience, however, the following conclusions are evident: That ample retention period should be considered in the design of settling basins for the application of chlorine and also for softening treatment for water at low temperatures. That better results will be obtained by double chlorination or by the application of chlorine prior to the application of lime. That the effectiveness of chlorine depends upon both the contact period as well as the pH value of the water at low temperatures.

Acknowledgment.—The foregoing is a paper presented at the 8th annual Three Day School of the University of Kansas and the 5th annual meeting of the Kansas Water Works Association.

WATER & WORKS SEWERAGE

Design ~ Construction ~ Collection
Treatment ~ Distribution ~ Disposal

August, 1930 — H. P. Gillette Editor — Vol. LXXVII. No. 8



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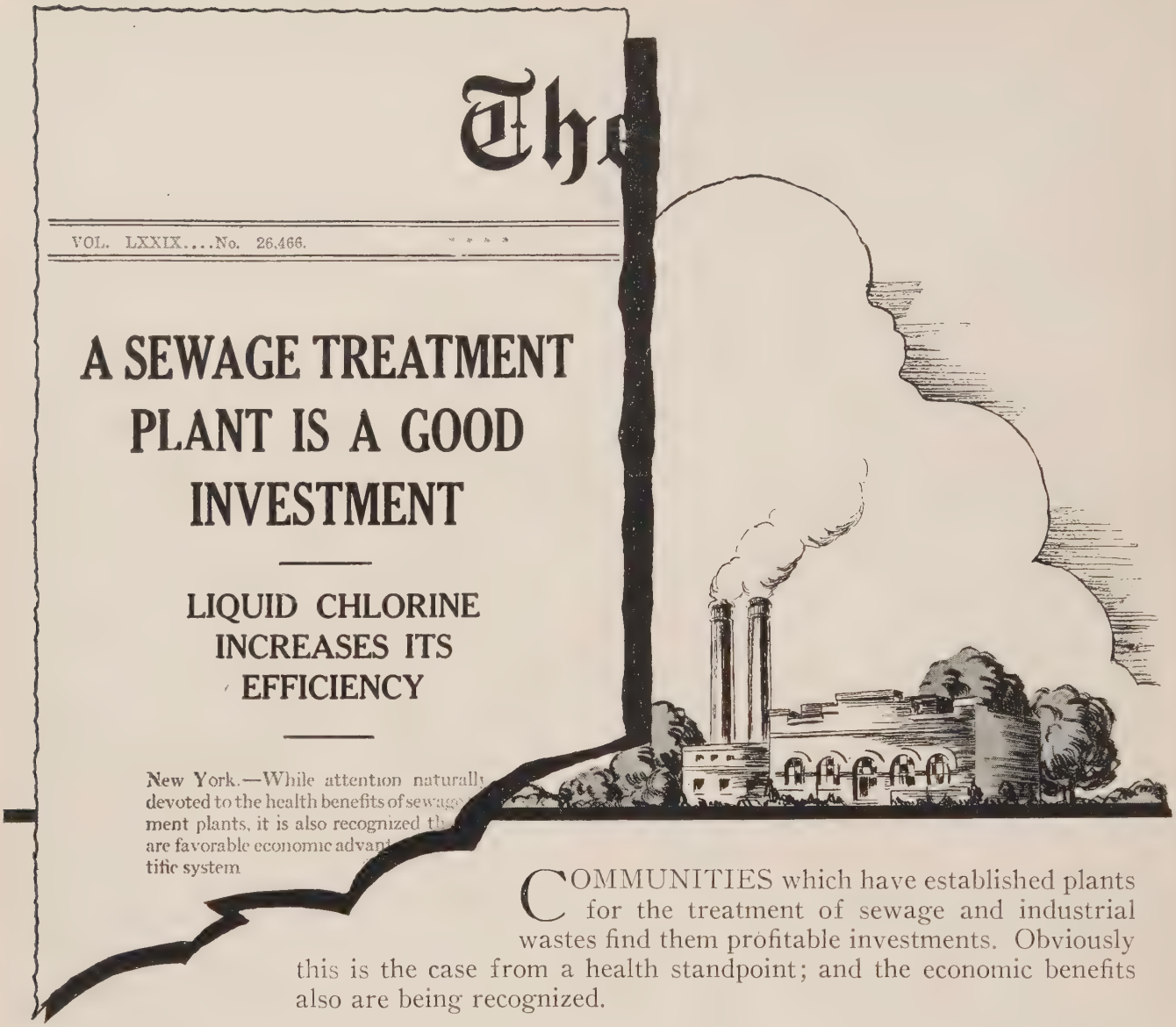

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Water Works and Sewerage

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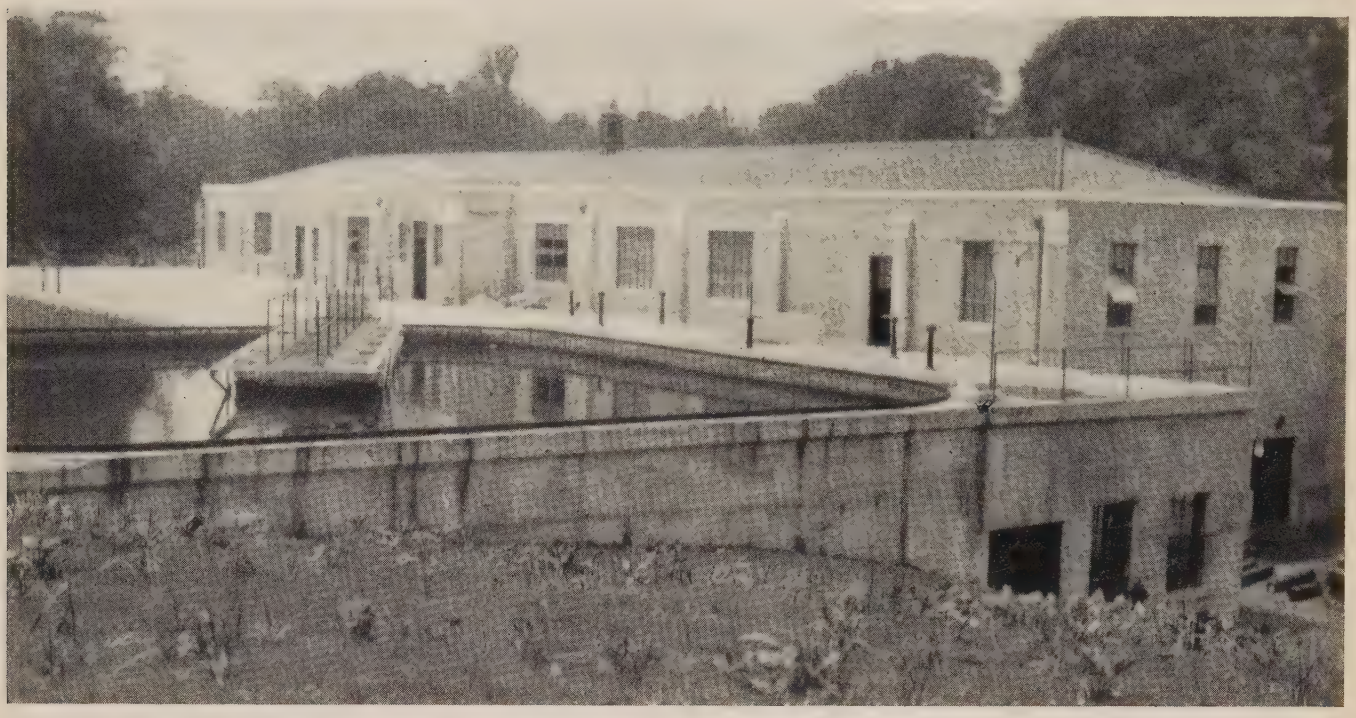


New Filtration Plant of Westchester Joint Water Works No. 1

Ferric Iron Coagulation at Mamaroneck, N. Y.

Successful Results of Experimental Runs at New Filter Plant Upon Water Resistant to Ordinary Methods of Purification Led to Continuance of Use of Ferric Iron

By ALEXANDER POTTER and WM. I. KLEIN

Consulting Engineers, New York, N. Y.

THIS plant, recently constructed for the Westchester Joint Water Works No. 1, serves the Towns of Harrison and Mamaroneck, the Villages of Mamaroneck and Pelham and portions of Rye and New Rochelle in Westchester County, New York.

Features Controlling Design. — The improvement was made to an existing plant supplying water to the various communities. The distributing system was without storage reserve; therefore, all changes, additions and betterments had to be made without shut down or stoppage of the pumps.

All new work had to be incorporated as part of the existent plant using such space as was available within the building, including space utilized by the pressure filter. The pressure filters had to be maintained in service until replaced by the new filters, following this they had to be removed and the building housing them converted into a 2-story chemical house. The new filters, filter house and settling basin had to be constructed on an irregularly shaped, rock outcrop of limited area, available around this pumping station.

The Mamaroneck River water was known to be difficult to treat. This stream, derived from a small watershed, without impounding reservoirs, represented practically a straight run-off, hence flashy, with rapid variations in chemical characteristics, color, turbidity, odor and taste. Its pH value is erratic; in general it is a soft, aggressive water, containing iron and manganese and possessed of a color or stain resistant to chemical treatment. Two impounding dams now under construction, on the watershed, will modify and correct these difficulties to a considerable extent.

Capacity of the filter plant is 5 M.G.D. with provision for expansion to an ultimate capacity of 10 M.G.D. All references that follow relative to retention time periods are based on this 5 M.G.D. rate.

This watershed, some 8.75 miles long with a total gathering extent of some 14.46 square miles is taxed to its limit to furnish this yield. This high yield, however, is based upon deficiency of stream flow during dry periods being compensated by diversion from New York City's reserve storage in Rye Lake (Kensico Reservoir).

Influence of these factors is responsible for a design of plant of wide elasticity in operation with provision to allow for variations in both chemical treatment and its application.

Water Treatment Plant.—The water derived from Mamaroneck River flows by gravity from the old dam just west of the new filter plant, through a 30-in. cast iron main to the electrically driven low lift centrifugal pumps, the battery of low lift pumps consisting of three units, each capable of pumping 3 M.G.D. against a 25-ft. head.

On its way to the low lift pump the water passes the chemical house wherein provision is made for chlorination

either as super or prechlorination to the raw water or for chlorination of the final effluent. Likewise means have been provided for the use of practically any form of known coagulant to raw water, likewise for any alkaline corrective treatment that may be required by either the raw or filtered water. This equipment in its entirety is within a chemical house provided with an hydraulic lift, with an upper chamber of large storage capacity, and with floor hoppers of the closed welded metal type for gravity flow to the dry feed chemical machines located directly underneath. All apparatus is in duplicate. Dry feed machines are provided with dissolving hopper and eductors to convey the chemical solution against head to the points of application. Also for emergency use one portable electrical dry feed machine is provided and available for application of chemicals at any point in the process of water treatment that may be desired.

Passing from the low lift pump the water is forced into either the mixing chamber, primary sedimentation basin of Dorr Clarifier type, or secondary sedimentation basins. The mixing chambers are two concrete tanks placed within the filter building in line with the filters. Each mixer is supplied by an underflow baffle from a central entrance chamber, provided with a hydraulic automatic control valve that maintains a fixed elevation of water in these mixers. Each mixer is provided with a 12-ft. diameter concrete throat in its center wherein revolves a motor-driven Dorr impellor agitator. The water previously treated with coagulant enters at bottom of the mixers, is agitated vertically by the impellor, as it crosses and finally reaches the opposite side of each mixer where it decants through an upper level port either into the Dorr clarifier or the secondary subsiding basins. These mixers are designed for an ultimate retention of 20 minutes. This apparatus is efficient; its action is beneficial in formation of mass floc; compact, operating without any appreciable loss of head; all of which are valuable and suitable adjuncts in the treatment of this water.

For primary subsidence a 60-ft. rectangular Dorr clarifier with capacity equal to one hour retention is utilized. Limitation of available space restricted the total settling period to three hours; therefore, a basin of this type (with its self-cleaning feature without interruption to service) is peculiarly applicable.

Sludge from the clarifier can flow by gravity to the sludge filters or by a sludge pump be recirculated to the mixer where a proportioning device feeds part or all of this sludge either into the mixing chambers or the sewer.

Recirculation of certain types of sludge has demonstrated that this process has merit. Its action induces mass floc formation that settles out quickly with only moderate increases in the chemical doses.

For secondary subsidence there are two covered concrete tanks, having a combined capacity equivalent to two hours, which used in conjunction with the Dorr basin furnishes a combined retention period, after mixing, of three hours, all that could be provided within the limited area available.

The filters consist of four filter units each of 1¼ M.G.D. capacity; with tank construction of reinforced concrete on rock foundation. Filter units have central flume with cast iron circular wash water collecting gutters, 27-in. depth of filtering sands superimposed on 16 in. of graded gravel.

The under drain system in each filter unit consists of two cast iron elliptical manifolds with brass laterals 2 in. in diameter and umbrella type strainers equipped with air trap tubes. The beds are washed by utilization of the air and water wash. Before applying wash water the bed as a preliminary to the washing process, is drained to 8 in. below the gutter lip, then agitated with air for a period of about three minutes, following which the wash water at a 15-in. vertical rise per minute is applied. Each filter is equipped with an effluent controller arranged to slow down automatically at times of high water in the clear water basin. Marble operating tables are provided for each unit equipped with indicating loss of head gauge and control valves for operation of hydraulic valves and sluice gates.

The effluent from each filter passes into a collecting flume directly under the pipe gallery, from which it rises through an illuminated sight or detector well to the influent flume of the aerator. This sight well is 4 in. by 4 in. white tile lined bottom and sides. The depth of filtered water visible is 10 ft. and the illuminant a high power daylight electric lamp. This detector sight well is extremely delicate in operation; it shows the slightest passing of color, turbidity or hydrate. Its particular merit is that it has all hands busy correcting any operating trouble before it becomes serious enough to impair the quality of water delivered to the distribution system.

The filtered effluent then passes over an open non-freezing type riffle plate aerator, thence into the clear water basin from which by either of three high lift DeLaval electric driven centrifugal pumps (each having a total capacity of 8 M.G.D. against 300 ft. head), the water is pumped into the distribution system, now provided with a 600,000-gal. storage elevated tank reservoir for smoothing out peak demands and as a stand-by to the distribution system.

Waste water from the filters and the settling basins is passed to a sludge filter to prevent fouling of the stream below the plant by sludge deposits.

For reliability and economy of operation a Diesel engine driven generating plant was installed in duplicate.

Operation.—The new filtration plant was started during the last week of February, 1929, operating with sulphate of alumina as the coagulant preceded by chlorination. Prechlorination in conjunction with this coagulant was essential at all times to insure complete color removal.

The optimum coagulation was found to be variable but always within a narrow pH range, necessitating daily laboratory determination for guidance of plant operation.

Vigilant care was required to prevent over or under dosing, both resulting in unsatisfactory or pin point floc formation, colloidal in character. Excellent heavy floc formation was at all times obtainable, using soda ash or hydrated lime, previous to the application of sulphate of alumina but their use intensified and set the color. Correction for aggressiveness was possible only after filtration. Applying corrective alkaline chemicals at any point before filtration would result in intensified and fixed color.

Aeration is of material benefit in removal of taste, odor and CO_2 with the consequent saving in amount of corrective chemical treatment after filtration.

With warm weather during the 1929 season came the drought. Low stream flow and algae troubles with intensified taste and odor in the raw water caused filter operating difficulties.

Control of algae by copper sulphate treatment of the stream, likewise the continuous feeding of this chemical mixed with granulated sulphate of alumina through the dry feed machines proved ineffective. The algae was found to be resistant to any control by use of copper sulphate. Instead of abating it increased. Slime algae grew on the sand in the filters, causing sand shrinkage, cracking, mud balls and short irregular filter runs. Super prechlorination with potassium permanganate treatment controlled the algae growth, cleaned up the filter sand, stopped the shrinkage and cracking and eliminated the taste and odor.

The chlorine absorption of the water was both variable and quite high. This was successfully controlled by operating on a fixed residual chlorine of 0.5 p.p.m. in the Dorr effluent. This provided an effluent free from gas formation and with safe bacterial counts. Summer was well advanced, however, before we could secure more than the necessary residual chlorine in the filter effluent; the heavy chlorine dose was consumed by oxidation in the sand beds.

When the residual chlorine began to increase in the filter effluent, the trouble was over, the beds were free of organic matter and the chlorine dose was reduced accordingly.

Potassium permanganate was applied by mixing it with the sulphate of alumina, apportioning a definite amount and mixing it with each bag of coagulant before it was dumped into the hopper of the dry chemical feeders.

The dose of potassium permanganate to start with was 0.2 p.p.m., increasing in amount with the intensity of taste and odor until during the peak the dose

reached a maximum of 0.45 p.p.m. for a short period, this dosage being reduced as the taste and odor in the raw water abated.

Plant treatment as outlined continued during and following the dry period, delivering a satisfactory effluent but accompanied by rigorous, vigilant watching and correcting of chemical dosage until January of 1930, when the river froze over and the raw water temperature dropped close to the freezing point. With this drop in temperature it became impossible to coagulate this water except by use of hydrated lime applied previous to the sulphate of alumina. Excellent floc formation was obtained but the filtered effluent had a fixed yellow stain and lime started to deposit on the sand of the filter beds.

At this time and under such conditions a plant scale experiment was made using ferric iron as a coagulant. The results were so satisfactory and far reaching in their benefits to the plant as a whole, with incident ease of control and operation that what was started only as an experiment has continued as routine plant operation.

Use of Ferric Iron. — Plant control, using ferric iron coagulant, is based upon two simple tests made by the filter attendant at the mixing chamber:

1. Observation of the character of the floc formed, using a floc detector. The operator's eye is quickly trained to tell the difference between good and improper floc formation. If there is any question as to whether the water has secured proper treatment filtering 50 to 100 c.c. through filter paper and noting color of resulting effluent is a quick and ready checkup. The sampling point for these determinations is at the effluent side of the mixing chamber, or 20 min. after the chemical dosage.

2. Determination of residual chlorine in water sampled from the influent side of the mixer where approximately 0.2 p.p.m. of residual chlorine, or higher, is maintained as may be required for control of algae growths, tastes or odors.

This last test is within a 5-min. period following application of the chemicals. It insures sufficient chlorine to react with all the iron, thereby preventing free iron from passing into the basins and also compensates for the variation in chlorine absorption of the raw water.

In so far as we have been able to determine from the action so far encountered on this water the best coagulating results are obtained by:

A—Preparation of the coagulant is made with close regulation of chlorine in an amount not to exceed by more than 10 per cent the theoretical requirements.

B—Prechlorination of raw water to an amount sufficient to secure a residual chlorine of approximately 0.2 p.p.m.

C—The application of chlorine for prechlorination is made separate from the application of the chlorine for the purpose of preparing the coagulant.

D—The coagulant is applied to prechlorinated water.

E—Anhydrous ammonia is applied to remove and prevent any chlorinous taste or odor. Anhydrous ammonia is applied to the filter effluent.

Under such control the operators have and are maintaining a sparkling, brilliant, plant effluent free from any taste or odor, with considerable ease of operation, especially so when contrasted with the use of sulphate of alumina as the coagulant on this plant.

Action of these two coagulants, on this particular water, compares as follows:

Comparison of the Action of the Two Coagulants

Sulphate of Alumina Coagulant	Ferric Iron Coagulant
Low temperature of water prevented floc formation, unless hydrated lime is used, resulting in set of yellow color in effluent and lime deposits on the sand beds.	Temperature of the water has no effect on floc formation even under the coldest condition of water with stream frozen over.
Good floc formation is only with a narrow pH Range.	During period of operation Raw Water has varied from a pH of 6.0 to 7.6 without any apparent action detrimental to or in favor of floc formation.
Over and under-dosing causes pin point floc formation of colloidal character that would not settle out in the available settling period.	Under-dosing will not throw down all color, and effluent will show stain and lack of brilliancy.
Color and hydrate pass filter resulting in clouded effluent.	Over-dosing has no deleterious action other than extravagant use of chemicals causing a heavier and more rapidly settling floc than is required, it shortens filter runs without impairment of quality or brilliancy of filter effluent.
The floc formed is very light and buoyant. The retention period available is not sufficient to cause efficient settling. Floc passes over on and blankets the filter beds causing short runs. Floc on filters so dense that wash water gutters are not visible through 3 feet of water.	Floc formed is heavy, settling quickly in the available basins.
Slightest variation in water level in settling basins stirred them up and brought heavy floc over on filter beds.	Small amounts of floc come over on filter beds, runs are lengthened and water while flocked sufficiently to produce brilliant effluent is clear so that not only the wash water gutters but the surface of the sand bed is clearly visible.
Three (3) hours settling period followed by filtration period: successfully handles flood conditions but due to characteristics of floc formation the filters carry a heavy burden that materially shortens the run period.	Variation in water level in settling basins as great as three (3) feet does not stir them up or cause heavy floc to come upon the filters.
The light feathery floc of this coagulant formed a dense mat upon the sand beds, causing trouble from air binding of filters—shortened run. Irregularity of flow caused released the accumulated air entrained in the gravel and lower sand layer, which bursting up through the beds destroyed their efficiency and allowed color and hydrate to pass through.	Turbidity increases weight of floc and rate of subsidence. Four floods have so far occurred, since use of ferric iron coagulant. The character of effluents from the Dorr basin have remained clear. So far flood turbidity has been controlled within a thirty (30) minutes settling period without any material increase of filter load.
Impossible to retard flow or stop filter, without passing color and hydrate. When necessary filters had to be taken completely out of service, washed and filtered to waste for thirty (30) minutes before effluent was safe to turn into filtered water basin.	This trouble was eliminated within forty-eight (48) hours following use of this coagulant at the plant.
With alum coagulant, despite the self-cleaning apparatus of the Dorr, due to lightness of floc and its accompanying slow settling characteristic, it has been necessary to clean the secondary settling basins monthly, due to the accumulation, during this period of time, of about an eight (8) ft. depth of sludge.	Use of Ferric Iron corrected this difficulty at once—Filters can now be shut down at any part of the run without damage from release of entrained air and started up without washing or filtering to waste delivering a brilliant water at all times. Since use of this coaguant we can operate intermittently by closing entire plant down from midnight to 4 a. m. during which period water is pumped from clear water basin storage.
Sand grains are coated with gelatinous films of alumina hydrate with all its accompanying filter operating troubles.	With use of ferric iron the same procedure of cleaning secondary settling basins each month has been adhered to but the accumulated sludge is only two (2) feet in depth. This is due to increased settling action in the Dorr occasioned by the heavier floc formation of the ferric iron.
	Sand is free from all gelatinous film and as clean as fresh new sand.

Acknowledgment.—The foregoing is an abstract of a paper presented at the St. Louis Convention of the American Water Works Association.

Milwaukee, Wis., Has No "Free Water"

The following note is extracted from the 1929 report of the Common Council of Milwaukee, Wis., on the municipal government and activities of the city:

The schedule of water rates first placed in effect in 1921 had been formally filed with the railroad commission on July 20, 1926, to be effective 10 days after this date, as provided by law, and on Dec. 9 of the same year, following a hearing regarding the reasonableness of the rates, the commission issued an order approving them. Several large water consumers appealed to the supreme court from a judgment rendered by the circuit court for Dane county which sustained the order of the railroad commission approving of the water rate. In a decision rendered by the supreme court on Oct. 8, 1929, the action of the railroad commission approving the following rates was affirmed.

For water furnished inside of the city a uniform rate of 7 ct. per 100 cu. ft., equal to 9½ ct. per 1,000 gal., and for water furnished outside of the city, 10 ct. per 100 cu. ft., equal to 13⅓ ct. per 1,000 gal. In addition to the charges for water consumed, there is a "service charge" of $2 per annum, assessed against every meter, regardless of the size of meter, service pipe, or quantity of water consumed. Automatic sprinklers are charged $25 annually for 4-in. connections and $50 for 6-in. connections. No free water is furnished to anyone.

Residual Chlorine Control

Experiences at Little Falls, N. J., and Rahway, N. J., with New Automatic Recorder and Controller

By J. WESTFORD CUTLER and FRANK W. GREEN

Experimental Engineer, Wallace & Tiernan Co., Inc., Newark, N. J.; Superintendent of Filtration and Pumping, Passaic Consolidated Water Co., Little Falls, N. J.

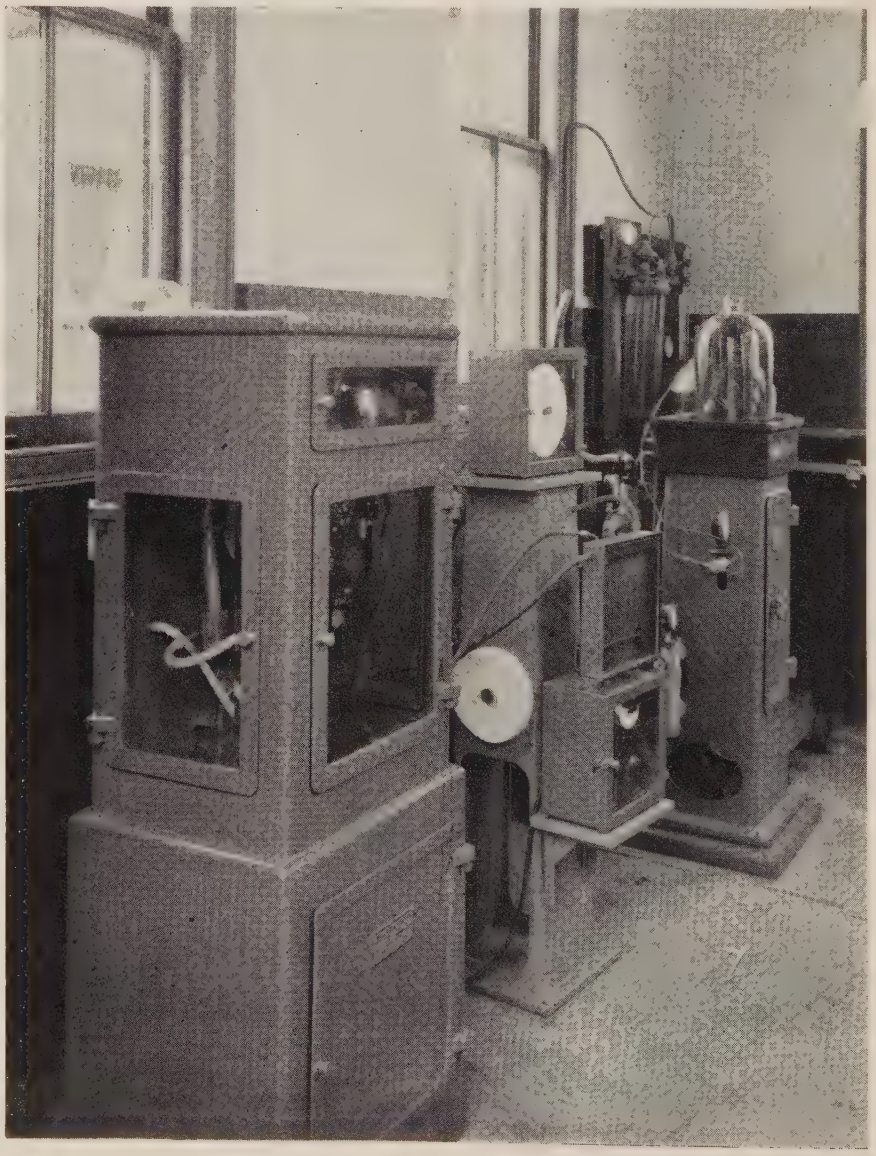
THE art of chlorination has become well established in the minds of the water works profession. Chlorination was started with the use of very crude equipment. Step by step this equipment was perfected.

When chlorine is added to water a certain amount is absorbed by substances in the water in addition to that required for the killing of bacteria. If more chlorine has been added than is required for such absorption there will be an excess which is commonly termed "residual chlorine." This residual is used as a safety factor, and because this excess is easily measured by the use of orthotolidin, it has been generally accepted as a standard control in water purification work. The difference between chlorine applied and chlorine residual represents the chlorine demand of the water and this chlorine demand varies over wide limits. In the light of these facts, a desire arose for a perfect control system whereby chlorination was accomplished not only automatically in proportion to flow of water, but would stand the test of legal cross questioning. It is apparent that such a control equipment would be a most useful tool in water works operation. Heretofore automatic equipment, although far better than manual, has not been the perfect control system. All variables involved in water treatment were not covered. Automatic equipment would compensate for changes in flow or pumpage, but not for any variation in the chlorine consumption of the water itself. It was necessary for the chemist to detect this change in chlorine demand by tests, and then manually adjust the chlorine dosage.

Few plants are able to use a constant chlorine dose, day in and day out, over long periods of time, and obtain a constant residual, because of the changes in flow and in demand. In order to be sure of a residual at all times various means are resorted to, such as carrying an overdose of chlorine; maintaining very careful supervision with frequent tests; or, in an increasing number of cases, applying automatic equipment to care for variations in flow. Where conditions are unusually erratic all three of these means are used. With all these precautions demand may still not be properly taken care of and there is no assurance on the part of those responsible for the character of the water delivered to the public that a residual has been maintained in every gallon of water delivered by their system. To overcome these difficulties the functions of the chlorine control equipment are: (1) It must automatically care for flow changes in the water treated. (2) It must adjust automatically the dosage for chlorine demand. (3) It must provide a legal 24-hour record. How these functions are performed in the new atuomatic residual recorder and controller will be described.

The New Automatic Recorder and Controller.—The world was benefitted when the great tool known as the photo-electric cell was perfected. Vastly complicated mechanical devices have been developed in and around these light sensitive cells, such as talking moving pictures, television, automatic counters, and high speed sorting machines for color, size or shape. These are only a few of the vast quantity of devices wherein the photo-electric cell is fundamental. These cells are obtainable in all sizes, shapes and kinds and a large majority are designed for special purposes wherein particular qualities are built into the cell so that it may perform a particular duty.

The cell which is the backbone of the Wallace & Tiernan residual control apparatus is of still another category and was selected for its ability to pass



Residual Chlorine Control, Little Falls, N. J.

a sufficient amount of current to operate the equipment in its circuit without additional amplification. The equipment is essentially simple, both in design and in operation. The electrical units and electrical circuits are not complicated. It has been found most practical to use an intermittent system wherein a record is made, chlorine dosage adjusted, and everything turned off for a period of time before a repetition of this cycle. The adjusting of the length of time between cycles is at the discretion of the operator.

There are four principal parts to one cycle of the apparatus. An electric motor starts and runs the machine through these four parts in their proper order and stops for the desired time interval. They may be listed as follows:

1. A light source must provide illumination in a manner which enables the photo-electric cell to measure and compare the color of the solution.

2. A mechanical relation must be set up which corresponds with this measurement.

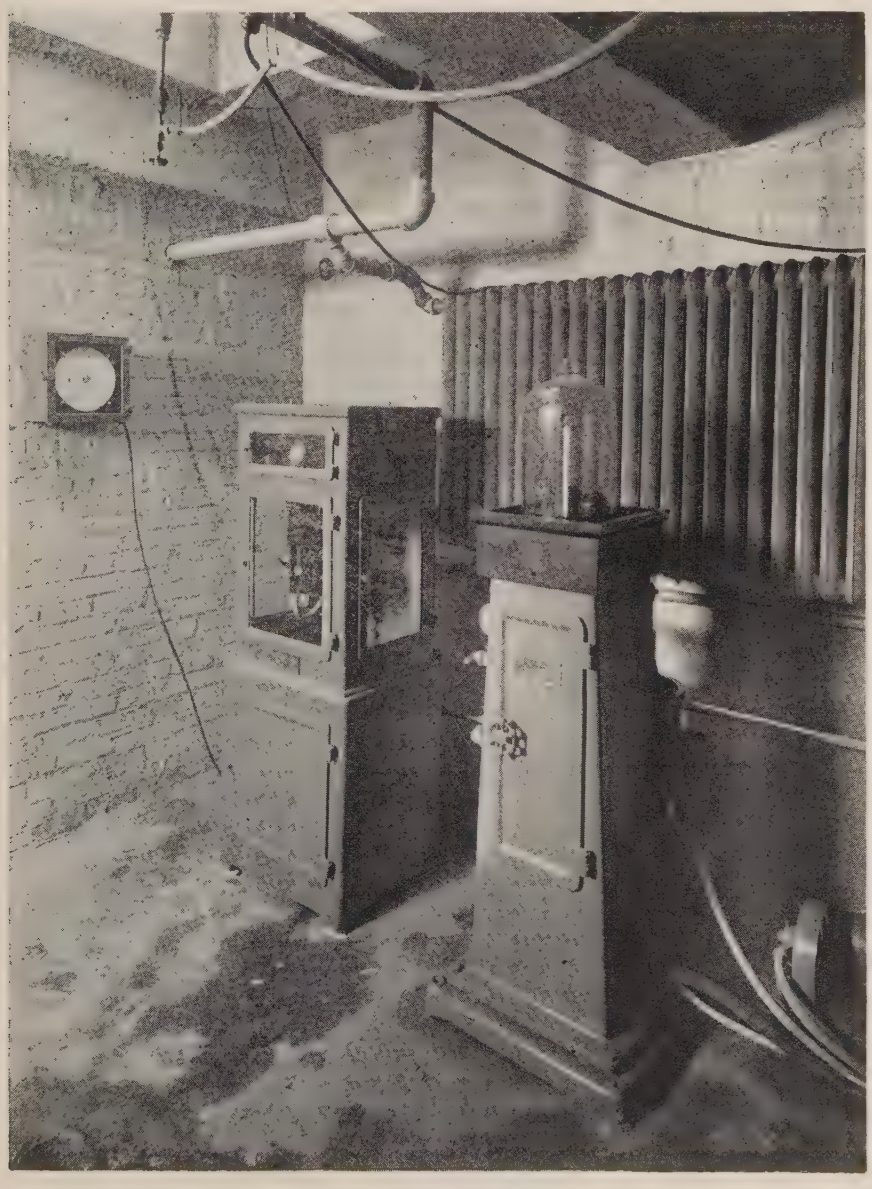
3. The above mechanical relation must operate a pen on a chart and adjust the chlorinator.

4. The apparatus must automatically obtain for itself a new and fresh sample of treated water and add the proper amount of orthotolidin at the proper point.

In order that these various departments perform their action in the proper order, the equipment is arranged to operate from two shafts, geared to each other with an 8 to 1 ratio. The slowest of these shafts makes one revolution for a complete cycle.

Operating Results.—The development of this machine has been the work of something over four years, during the course of which four models have been built and operated.

The first practical installation was made at Little Falls, N. J., in August, 1929, at the plant of the Passaic Consolidated Water Co. This plant has a 75 m.g.d. output wherein a river water is filtered, chlorinated, and pumped to Paterson, Passaic, and several other communities.



Residual Chlorine Control, Rahway, N. J.

At first the installation was made taking a sample of the entire output of the plant and making a record of the variations in residual of the delivered water. Between August and the end of December, 1929, after several minor changes were found necessary, it was sufficiently proved that the apparatus was suitable and safe to attach to a chlorinator and proceed with the original design—that of control of chlorination by residual. Therefore, in January the equipment was moved and attached to an automatic chlorinator. This was to control the chlorination of a certain section of the Little Falls Station. The output from a 63 m.g.d. battery of gravity filters flows by gravity some several hundred feet to the pumping station and in this suction line there are two chlorine applications, the sum of which constitutes chlorination for this section of the system.

First, some 125 lb. of chlorine are added to the water from a series of electrolytic cells and on top of this an auxiliary chlorinator adds a variable amount of chlorine of approximately 50 lb. average as an adjustable trimmer. This adjustable trimmer supply of chlorine is connected to the residual control outfit. The pump discharge returns to a point very near the location of the chlorinators and a sample line is brought over to the residual controller. In this manner there is a lag of 10 minutes between the point of application of chlorine and the supply box at the rear of the residual controller. After correcting a number of minor mechanical difficulties, some of which were due to an unusual current source of 220 volts d.c. for which the machine was not designed, the entire assembly of apparatus functioned satisfactorily.

Manual orthotolidin tests, taken as a check on the apparatus at frequent intervals, showed that the controller was picking up the variations in demand and flow. An 80-lb. chlorine meter on the chlorinator was frequently called upon to change over its entire scale in response to these demand changes.

The 10-minute lag between application and sample, while annoying at times, was found to have no serious effect upon the final result. It was very gratifying to note on several occasions that unexpected changes in output from the chlorine cells were compensated for very promptly by the controller.

Some little difficulty was encountered with the long interval required to develop color in the cold water flowing during the months of January and February, but the use of a stronger concentration of the orthotolidin solution and slightly warming the water corrected this condition without impairing the quality of the results obtained.

Careful observations by officials of the Little Falls Plant showed satisfac-

tory control between 0.18 and 0.21 p.pm. At various times the standard glass was changed rendering a different range of control.

Early in April, 1930, another installation was made in a water works of different character—that of the municipal plant at Rahway, N. J. This plant pumps less than 6,000,000 gal. per day and desires to maintain a residual between 0.05 and 0.1 p.p.m. in fear of taste difficulties frequently encountered with high residuals. This installation was made in a 30-ft. run of exposed filter effluent line, running from the filters to a covered clear well. The chlorine was applied at the beginning of this 30-ft. 24-in. line and a sample was taken about 25 ft. beyond the point of application. This was necessary because of a 2-hour detention in the clear well before a sample could be obtained. The velocity in this pipe averages about 2 ft. per second and there seemed to be sufficient mixing for the sample to be a true one at the machine. In order to be certain of time for chlorine absorption a retention of 5 minutes was added to this sample before it entered the machine. Time for development of color was of course allowed in the machine itself. Operating on this short line a very snappy control was obtained and the standard was set for approximately 0.15 p.p.m. in order to control a 0.05 p.p.m. residual after the 2-hour interval. While this installation has not been in use very long the evidence available to date assures its success.

Adaptability of Residual Control System.—The system of residual control is adaptable in many ways other than the two just mentioned. It may be used as a warning of approaching pollution by locating the machine upstream and the chlorinator far enough downstream to protect the water supply when the controller indicates the need of increased chlorination to protect the water. The design is such that even miles may intervene between controller and chlorinator. For Great Lakes water supplies this feature offers innumerable arrangements to indicate points of sudden high demand and protect the consumer. Large savings in chlorine will often result and a great deal of responsibility from a legal point of view can be automatically taken care of. It may even be contended that the record offered by this equipment, and the legal significance thereof, will be its greatest advantage to water works users.

Not only, however, is the machine adaptable to chlorination. Experiments are already well under way for the application of this machine to hydrogen ion control. There is no question, but that it could be used in the regulation of turbidity or natural color in the water, and several cases have been brought to the attention of the developers for industrial uses.

The art of chlorination has again progressed. Another great tool has been added to the list of photo-electric devices. Another advance has been made in the protection of public health. As a process it is in a well developed stage. As a mechanical device, it is functioning well and will continually be improved as experience indicates.

Acknowledgment.—The foregoing is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

Odor and Taste Control at Charleston, W. Va.

By LAWSON HAYNES
Filtration Superintendent

During the winter months of 1929 and 1930 phenol wastes in Elk River caused obnoxious tastes and odors in the water supply of the Charleston Plant.

This condition existed during severe cold periods, when the temperature of the river water was near the freezing point, and also during the period of thaw following a severe cold spell. Conditions were at their worst after a protracted thaw when large quantities of water were coming from the water shed, carrying into the river, oils and phenol wastes that had accumulated on the ground and around industrial plants during the periods of freezing weather.

Use of Potassium Permanganate.—The first treatment applied to the raw water was 2 per cent solution of Potassium Permanganate which was fed into the discharge from the low lift pump and before the water entered the sedimentation basin. Potassium Permanganate was first applied at the rate equal to .12 p.p.m. being increased later to a maximum of .18 p.p.m. This treatment gave a slight color to the water entering the sedimentation basin but the color soon disappeared from the settled water. For a slight phenol taste this treatment seemed successful, but when a larger amount of phenol was present we were not able to combat it satisfactorily.

We are unable to state what effect larger dosage of potassium permanganate would have had on the finished water as representatives of the State Department of Health requested us to try the anhydrous ammonia treatment as they regarded this treatment as the one that would be most successful.

Anhydrous Ammonia and Potash.—With permanganate applied in the pump discharge anhydrous ammonia was introduced into the settled water just prior to filtration. This treatment was successful in removing phenol tastes but no chlorine residual could be detected in the clear well due to the reaction of the ammonia on the chlorine. However, laboratory experiments showed that a sample of water from the clear well, after standing for about one hour, had a chlorine residual. No tests were made at the time to determine chlorine residual in the distribution system. This latter test should have been made but conditions obtaining at the time experiments were being made with the treatment would not permit of same. During the test above mentioned we applied permanganate at the rate of .18 p.p.m. and anhydrous ammonia at the rate of .12 p.p.m.

Ammonia Successful.—The next experiment in the treatment was to eliminate the potassium permanganate and apply ammonia into the raw water intake to the basin. The point of application was such as to allow a period of contact of 1½ minutes before the raw water entered the sedimentation basin. A chlorinator was installed to chlorinate the water at the point of entry to the basin. Ammonia at the rate of .12 p.pm. was first applied and increased later to .18 p.p.m. and sufficient chlorine was applied to maintain a residual of from .2 to .3 p.p.m. at the influent end of the sedimentation basin.

This method of treatment was started at 3:00 p. m. on Feb. 1, 1930. At that time a very decided phenol taste existed in the raw and also in the finished water. Numerous complaints were received at the filtration plant and local office regarding the taste of the water. By 7:00 p. m. that same day no tastes could be noticed in the finished water at our plant and by the following morning complaints had ceased. Since that date when phenol compounds are liable to appear in the raw water the ammonia—chlorine treatment is started and continued until tests on the raw water show no phenol present.

Acknowledgment.—The foregoing is a paper presented at the 5th annual conference on Water Purification of the West Virginia State Health Department and the Engineering School of West Virginia University.

Texas Sanitarians' Short School.—The 8th Texas Sanitarians' Short School will be held at Amarillo, Aug. 26, 27 and 28, with Herring Hotel as headquarters. Local city and county officials are expected to arrange for sending representatives as usual to receive the benefit of the special training on water supply protection and purification, sewage disposal, milk sanitation, food protection, mosquito control, swimming pool sanitation, camp sanitation, general nuisances and menaces to health. The school is under the joint auspices of Texas State Department of Health, Texas Association of Sanitarians, and City of Amarillo. Dr. H. H. Latson, city health officer, is general chairman; and Jack Wyatt, director of the school, Amarillo; Dr. J. C. Anderson, state health officer, Austin; Dr. H. K. Read, president, Texas Association of Sanitarians, Houston.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor
Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

Two Questions Answered

What is the best material for large trunk sewer lines: Concrete poured in place, or precast concrete lined either with tile or brick, and if the latter, should the lining be complete or only in the lower half of the sewer?

This is a big order for a column of this kind since each case should be decided by competent engineers on its own merits. The question probably arises from the publicity given some time ago to the failure of concrete sewer outfalls in Los Angeles, Calif.

The writer's experience would indicate that concrete can be made to stand almost any condition that would be encountered in an outfall sewer if sufficient care be given to the preparation of the concrete and especially to its placing. There are exceptions in the case of particular trade wastes.

Aside from the use of the best of materials and the use of the proper proportion of water, of equal importance with these considerations is the rodding in of the mixture so as to eliminate all air spaces and make the most dense concrete possible. A dense, smooth original surface must be obtained by proper care of forms and by "cutting in" next to the form with a broad thin blade. Patched or resurfaced concrete will not stand the gaff.

Failure of concrete sewers, such as that at Los Angeles, is usually associated with high sulphate content of the sewage. As soon as the sewage becomes at all stale, bacterial action starts in with the production of large quantities of hydrogen sulphide (which is potentially sulphuric acid so far as its effects are concerned). This condition is particularly apt to give trouble wherever sea water may gain access to the sewer lines.

The disintegration of concrete under such conditions sets in at, or above, the flow-line; not beneath the water. There are several reasons for this: the liquid forms a protective coating on the concrete which is absent above the water line, the hydrogen sulphide requires oxygen to get in its worst work; this oxygen is present in the moist air above the liquid, but not in the stale sewage itself, and finally the alternate wetting and drying of the upper part of the sewer permits concentration of the acid which could not occur in the liquid itself.

The above explanation will answer the last part of the question, "Should tile lining be complete or only in the lower half of the sewer?" If one were to half-line the sewer he should line the top, not the bottom.

If conditions are such that a lining seems to be required, particular attention should be given to the quality of the mortar used in the joints. Ordinary mortar is very absorptive and placed in thin layers between tiles presents optimum conditions for disintegration by hydrogen sulphide.

Where the sulphate content of the sewage is such as to indicate possible trouble from disintegration by hydrogen sulphide, application of liquid chlorine to the sewage to prevent formation of this troublesome gas would be in order.

In considering the relative economy of tile lining of the upper half of the sewer as compared with that of treatment of the sewage with chlorine, it should be remembered that the chances are that the sewage would have to be chlorinated for odor control anyway and that prechlorination at some point up the outfall sewer would kill both birds with one stone.

We have two circular digestion tanks with provision for heating, circulating and adjusting the reaction of the sludge also for collecting the gas under safety covers. After filling the first tank and working the reaction up to the proper point and the temperature up to 77° F. we were getting 3,500 cu. ft. of gas per day. Then we let the first tank stand, while we started filling the second, and in a very few days the gas flow from the first tank stopped. Do you think that the gas is getting away somewhere?

No the gas is not getting away. You simply are not getting any gas because, as you say, you are "letting the tank stand." In other words, you are not adding any fuel to the process and the process stops when the available supply is exhausted. In order to secure a steady flow of gas you must add a steady supply of fuel just as you must supply fuel to a fire to keep it burning.

Now that the gas has stopped flowing, if you begin making regular additions of green sludge daily the gas will soon begin to come off again, but not in full flow for about two weeks, at which time there will be a very violent ebullition of gas. After a few days this will quiet down and you will again have a steady dependable flow as long as you supply a steady dependable quantity of fuel, and keep the temperature up. You may have to readjust the reaction during the interim, but this will require little attention once you get the tank back in its stride as to gas production and maintain a steady food supply.

Use of Sewage Gases by Public Utilities

The 1930 meeting of the Pennsylvania Sewage Works Association was held at State College, Pennsylvania, on June 26 and 27.

Accommodations and arrangements for the meeting were most excellent and a great deal of forethought and good judgment were shown in preparing the program, with the result that there was no crowding of formal papers and no dull moments when the program dragged. This is a happy balance which it is easier to talk about than to attain.

One was much impressed with the hearty participation of the operators in the program, which while being the aim of these meetings is also difficult of attainment.

During the formal meeting the operation of the various plant units was discussed by picked leaders and the discussion was carried on freely during an evening social session featured by the reading of numerous questions which had been asked and which were referred to various persons by the chairman for opening of the discussions.

The impression left by this meeting was a feeling of satisfaction with the progress that is being made in the art of sewage disposal and in the development and spread of information. The grasp which the men in the field showed of the latest developments offered by scientific research is both surprising and gratifying.

The outstanding paper of the ses-

sions, one which provided much new information, was one by Mr. W. H. Fulweiler, of the United Gas Improvement Co., on "Gas Collection at Sewage Treatment Works."

Mr. Fulweiler is not primarily interested in the sewage field, but was called upon by the United Gas Improvement Co. to investigate reports of German origin on the possibility of the recovery and sale of sewage gases to public utilities at a profit.

While his final conclusions were that the sewage gas is insufficient in quantity and unsuited by its characteristics to be interesting to the utilities and that the profits reported in Germany could not be other than a matter of bookkeeping between different municipal departments, these conclusions were drawn only after a very thorough and exhaustive study of the matter, which brought to light several facts which seem to have heretofore escaped the attention of men in the sewage field.

Comparing an average of analyses of sewer gases from different sources with the analysis of various gases commonly used by utility companies he showed that the sewer gas is a slow moving and sluggishly burning gas because of its comparatively high specific gravity. The high specific gravity is the result of the entire absence of hydrogen which forms from 27 per cent to 50 per cent of other gases commonly so used.

In burning gas it is caused to issue from the burner at a rate sufficiently in excess of the speed of flame propagation so that the flame will continue to burn at the tip of the burner and not flash back.

Since the rate of flame propagation of hydrogen is 16 ft. per second and that of methane (the principal constituent of sewer gas) is but 3.9 ft. per second, the ordinary gas burner is not at all suitable for burning sewer gas because the flame would tend to blow away from the burner.

Many of us who have watched experiments with the burning of sewage gas, will readily recognize Mr. Fulweiler's scientific explanation of the peculiarities which we have observed in the flame, and will set about looking for more suitable types of burners than now used. As he pointed out, however, it would not pay the utilities to go to the cost of altering equipment, particularly as the available quantity of sewage gas could never exceed about 1 per cent of the domestic requirements of our communities.

The high specific gravity of the sewer gas would greatly complicate its distribution. As an apt illustration it was pointed out that to force 20,000 cu. ft. of gas per hour through five miles of 4-in. main would require 40 hp. in the case of sewer gas as against 24 hp. in the case of coke oven gas.

While the sewer gas would be valuable as an enriching agent because its heating value is comparatively high, 750 B.t.u. against 550 for manufactured gas, it was pointed out the equipment required and cost of transporting the gas would render the application of this idea impractical in most cases.

Not satisfied with presenting the negative result of his study from the point of view of the utilities, the author took up the possibilities of the use of the gas about the sewage plant as for heating sludge and indicated that the gas does pay a profit when so used, because by making possible the use of smaller tanks it saves on capital costs and consequently on interest charges.

The paper contains several interesting tables and charts on comparative analyses, gas production, gas consumption, etc.

Sewage Disposal Plant Operation at Milwaukee, Wis.

The sales of a fertilizer called Milorganite during 1929 paid about 68 per cent of the cost of operation of the sewage disposal plant of Milwaukee, Wis., according to the 1929 report of the Common Council on Municipal Government and Activities of the city.

Operation and maintenance of the Milwaukee metropolitan sewage system, including both collection and disposal of sewage, involved a net cost of only 66½ ct. per capita for the entire year of 1929. This does not include capital charges. A vast reduction in the expense of the system has been effected by the sale of fertilizer called Milorganite which is manufactured from the suspended solids removed from the sewage. The plant produced 34,933 tons of Milorganite, almost 100 tons a day, and shipped 31,600 tons, for which an average price of over $20 a ton was received. The demand for fertilizer exceeds the Milwaukee output and is expected to continue to do so for many years.

About 70 per cent of the output is shipped to fertilizer manufacturers who blend it with other ingredients such as phosphates and potash and sell this product for use mostly in the states that grow cotton and tobacco. The remaining 30 per cent is sold for use directly without the admixture of any other material. This unmixed Milorganite is especially valuable for the growing of fine lawns and for general garden use. Most of this part of the output goes to golf courses, park boards, and other places where fine lawns are maintained. A considerable amount is sold in 100 lb. bags to the gardeners of Milwaukee and the surrounding suburbs. These local sales in 1929 brought a return of approximately $10,000. The retail sale price is $1.50 per 100 lb. bag.

The plant treated from 85,000,000 to 1,000,000,000 gal. of sewage per 24 hours. During each day there is a peak load on the plant which amounts to from 130 to 140 million gallons in 24 hours. The total time of by-passing due to storms was 7.8 per cent of the total number of hours in the year. In other words, 92.2 per cent of all the sanitary sewage brought to the disposal plant during the year was purified, the balance being taken care of by dilution in the rivers and lake.

The cost of the plant operation only, not including any capital charges nor any part of the operation of the intercepting sewer system, in the city and the metropolitan district, is approximately $950,000 annually. At the present rate of production and the present price, the sale of the Milorganite returns about 68 per cent of this amount. The profits realized last year totaled about $630,000.

Tentative plans were made by the chief engineer for additions to the plant which will provide capacity for sewage from the city and suburbs up to 1950. There will be an addition to the dryer house the size of the present building, and three new dryers will be installed.

At the beginning of 1929 an elaborate cost keeping system, which makes it possible to determine accurately the cost of every phase of plant operation, was put into effect.

Introducing chlorine gas into the dryer discharge again proved a very successful method of eliminating the odor nuisance. Very few complaints on this score were received in the course of the year. While the chlorine treatment was originally considered only a temporary expedient, and other methods were carefully investigated, it was found that chlorine was superior in its effect and lower in its operating costs. About 50 tons of chlorine were used during 1929 at a cost of $3 a 100 lbs.

Special Truck Aids Meter Changes in St. Louis

Special trucks for handling water meters are in use in St. Louis, Mo. The special body, which is mounted on a Ford 1½-ton chassis, carries three transverse frames made of 3-in. channels. The frames carry a 5-in. longitudinal I-beam, arranged so that it may be pulled out to project 3 ft. beyond the rear of the body or pushed forward to extend over the roof of the cab. A trolley runs the full length of the beam on the lower flange, and stops are provided at each end. The trucks are useful in replacing large meters set at the curb. Four men were formerly required for this operation, which is now handled easily by a crew of two. Large hydrants and valves are also handled by the trucks.

The trucks are equipped with side lockers and a front locker just back of the cab. The lockers are provided with receptacles for storage of tools and supplies.

Taste and Odor Removed by Activated Carbon

Results of Experimental Work Conducted in 1929 on River Water Containing Objectionable Odors

By GEORGE D. NORCOM and R. I. DODD

Respectively Sanitary Engineer and Chemist, Federal Water Service Corporation, New York, N. Y.

DURING the past two years a considerable amount of attention has been directed to the use of activated carbon for the removal of odor and taste from water supplies. The experimental work which has come to our attention has dealt particularly with the removal of residual chlorine, phenols and chlorophenols. The studies described in this paper have been carried out on river water which had been purified by passage through a rapid sand filter plant. The raw water contained objectionable odors and tastes all of the time and the filtered water contained them to a lesser extent the greater part of the time. These odors and tastes are not due to any one substance but rather to a mixture of substances and at no time could the odor or taste of phenols be specifically detected. The activated carbon has been used in the treatment of this water in such a manner as would be indicated in actual purification practice so that the results should be truly comparable to those which might be secured with a large scale plant.

Description of the Raw Water.—The raw water for the purification plant was secured from the Delaware River at Chester, Pa. The watershed of the Delaware includes a very highly developed industrial territory and here will be found manufacturing plants of almost every type. The wastes from most of these plants eventually reach the river and many of them are of such a nature as to cause objectionable taste and odor in water. The odors most frequently encountered are those caused by the wastes from oil refineries, paper mills, chemical plants and organic matter of domestic origin. With the large dilution afforded by the river and the slow progress of the pollution downstream due to ebb and flow of the tides, the agencies of self purification exert a very beneficial effect, but in spite of this the water at Chester still contains objectionable odors and tastes. Summaries of the intensity of the odors and the predominating types of odor are given in Tables I and II. It will be noted that the intensity is greater during the cold months. Another interesting feature is that a sample of water giving an oily cold odor develops a musty odor when heated. This is probably due to the fact that heating removes certain volatile odors and this permits the detection of other underlying odors of a different character which are classified as "musty."

Preliminary Purification.—In all but one of the experiments the water applied to the carbon filters had been purified by passage through a complete modern rapid sand filter plant employing the following processes in the order named:

1. Pre-chlorination sufficient to produce a residual of about 0.5 ppm. chlorine.
2. Treatment with alum and lime to produce coagulation.
3. Cascade aeration.
4. Sedimentation for about 3 hours.
5. Filtration through sand.
6. Secondary lime treatment for the prevention of corrosion.
7. Secondary chlorination.

The effluent of this plant was free from turbidity at all times and contained a residual chlorine content of 0.2 to 0.4 ppm. The chemical characteristics of this water are indicated by the appended analytical results.

Activated Carbon Experiment, 1929
Sanitary Analyses of Filter Plant Effluent and Effluent Carbon Filter No. 5
Parts per Million

	Filter Effluent Laboratory Tap	Effluent No. 5 Carbon Filter "Darco"
Serial number	S-13983	S-13984
Date of collection	10/16/29	
Date of examination	10/22/29	
Cold odor—20° C.	3 Musty-Earthy	1 Aromatic
Hot odor—90° C.	3 Arom.-Musty	1 Aromatic
Turbidity—silica standard	0.	0.
Color—platinum standard	5.	0.
Oxygen consumed	2.5	2.2
Nitrogen as free ammonia	0.278	0.006
Nitrogen as albuminoid ammonia—total	0.124	0.084
Nitrogen as nitrites	0.015	0.003
Nitrogen as nitrates	0.800	0.800
Chlorine	7.0	10.0
Alkalinity	34.0	37.0
Hardness, by soap method	77.1	80.0
Hydrogen ion concentration, pH	6.6	6.7
Iron	0.10	0.10
Residue on evaporation—total	170.	170.
Mineral residue—total	125.	120.

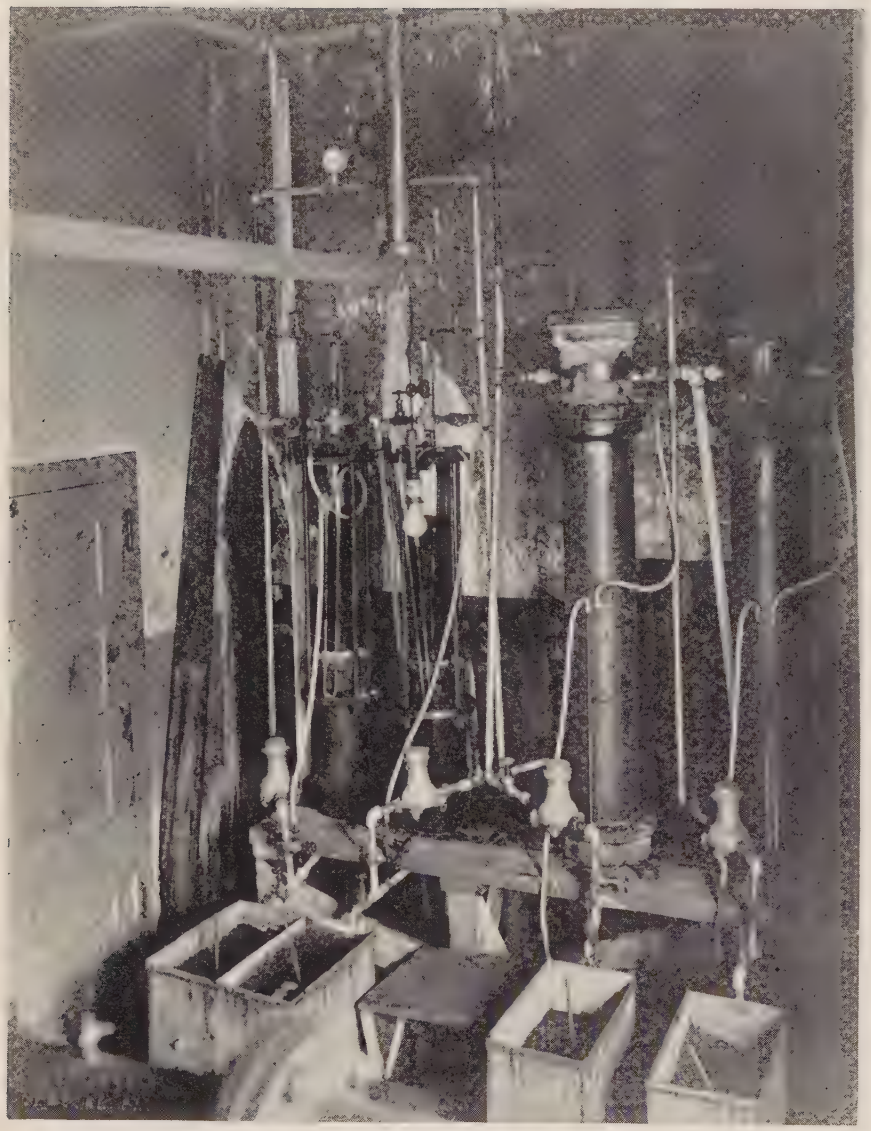
Table III shows the predominating odors in the treated water and the frequency of their occurrence. In Table I the average intensity of the odors is given and the detailed results are graphically depicted on the accompanying chart. The reductions in the intensity of raw water odor effected by the purification plant were 68 per cent for hot odor and 78 per cent for cold odor, based on the averages.

Methods of Odor Determination.—Due to the changing character of the tastes and odors and the varying mixtures of the substances producing them, no simple analytical method has been devised for accurately measuring their quantities. In the absence of a definite parameter it was necessary to fall back on the methods for odors described in Standard Methods of Water Analysis. The limitations of these methods are known to all since they depend on the judgment of the observer and his ability to detect and evaluate odors. Fortunately we were not compelled to rely on one observer alone, many observations were checked by another observer and it was frequently possible to conduct blindfold tests with from 3 to 5 trained observers participating. Doubtless a number of irregularities occurred, but every effort was made to render a fair judgment on all samples examined.

The technique for hot and cold odor was carried out according to Standard Methods but a slightly different system of evaluating the odors was employed. Standard Methods use numbers from 0 to 4 to express a gradual increase of odor and then jumps to 5 for a water whose odor is such as to make it unfit for drinking. We have used the same numerals but have tried to divide the scale of odors from 0 to 5 into even steps.

Observations of hot and cold odor and cold taste were made on all samples of treated water and carbon filter effluents. Observations of taste were not made on the raw river water. In general there is a close relation between odor and taste but our results indicate that the intensity of the taste is usually less than that of the odor. Hot odors are generally of greater intensity than cold odors. For the purpose of judging the efficiency of carbon it is felt that the results for odor are all that is necessary and for this reason, and in order to avoid a multiplicity of data, the results of observations for taste have been omitted.

Description of Experimental Filters.—In the beginning a number of experi-



Experimental Filter Used in Activated Carbon Experiments

ments were run using filters constructed of 2 in. glass tubing. These experiments were sufficiently promising to cause us to repeat them on a larger scale. Pressure filters Nos. 1 and 2 were then constructed of 4 in. glass tubes. The remainder of the filters were constructed of 8 in. cast iron pipe. Each filter was provided with a perforated pipe gird in the bottom, an overflow for wash water, a mercury U tube loss of head gauge and a rate controller. The accompanying photographic illustration and drawing are representative of the installations. All filters were provided with high pressure wash water and all except the glass pressure filters had an auxiliary connection at the bottom for steaming.

The pressure filters contained 4 in. of graded gravel, 2 in. of filter sand and 30 in. of carbon. A 20-mesh copper screen was placed above the carbon. The available pressure was 60 lb./sq. in. The downward flow gravity filters also contained 4 in. gravel, 2 in. sand and 30 in. of carbon, and were provided with copper screens. Later the screens were removed on filters 3, 4, and 6. The total available head on all these

Table I—Intensity of Odors (1929)
(Monthly Averages)

	Raw Water		Plant Treated Water	
	Hot	Cold	Hot	Cold
January	3.5	4.7	1.15	0.73
February	5.0	5.0	1.26	0.96
March	4.3	4.6	1.44	0.90
April	3.7	3.9	0.92	0.63
May	2.9	3.4	1.00	0.54
June	3.0	2.8	1.19	0.65
July	2.8	2.7	0.96	0.39
August	3.8	3.7	1.16	0.26
September	4.0	3.6	1.00	0.73
October	4.0	4.0	1.32	0.64
November	4.8	4.6	1.81	1.08
December	4.8	5.0	1.65	1.55
Average	3.9	3.9	1.24	0.84

filters was about 6 ft. The upward flow filters Nos. 7 and 8 contained 6 in. gravel and 36 in. of carbon and the total available operating head was 2 ft. These filters had no screens. The freeboard between the top of the carbon and the overflow pipe was 24 in. on all filters.

The carbons used had the following characteristics:

Nuchar	Eff. size 0.51	U.C. 3.72
Darco	Eff. size 0.55	U.C. 1.8

Minchar: No analysis available.

General Remarks on the Operation of the Experimental Filters.—Above is given analytical results of a sanitary analysis of the effluent of Darco filter No. 5 compared with a similar analysis of the filter plant effluent. It will be noted that the carbon effected a reduction in the nitrogenous matter as shown by the free and albuminoid ammonia. The absorption of carbonaceous organic matter, shown by the oxygen consumed, is not so marked. The various mineral constituents remain unchanged by the carbon.

The removal of residual chlorine was not made the subject of particular study in these experiments. Orthotolidine tests were made occasionally on the various carbon filter effluents and were negative in every case except with the Minchar filters No. 4A and No. 6. The effluents of these filters showed traces of residual chlorine on almost all tests.

Carbon filters were not operated directly on the raw water except for a short time at the beginning of the experiments. It was found that with raw water the carbon bed soon became dirty and clogged due to the presence of turbidity and organic matter. In using the softer activated carbons like Darco and Nuchar on turbid water it is necessary for the water to be completely clarified by preliminary purification. The harder activated carbons, like Minchar can be used to filter tur-

Table II—Raw Water Predominating Odor
Per Cent of Time When Predominating Odor Was:

Month	Oily		Gasoline		Vegetable		Musty		Sewage		Disagreeable		Tarry		Fishy	
	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold
January	25	78	0	18	7	..	19	....	30	....	15	..	4	4	..	..
February	43	100	..	....	..	..	9	....	48	....	....	..	..	..	..	..
March	32	88	8	0	..	..	....	....	64	12	....	..	..	..	..	..
April	4	58	..	19	..	..	11	....	58	19	19	4	..	..	..	..
May	4	58	..	27	..	..	46	7	46	8	....	..	4	..	..	..
June	4	72	..	20	..	..	24	....	64	8	....	..	..	..	8	..
July	4	54	..	11	4	..	42	31	50	4	....	..	..	..	..	..
August	4	96	..	4	..	..	22	....	63	....	....	..	..	..	..	..
September	....	100	..	....	..	..	....	....	100	....	....	..	..	..	..	..
October	19	100	..	....	..	..	7	....	74	....	....	..	..	..	..	..
November	....	100	..	....	..	..	33	....	67	....	....	..	..	..	..	..
December	55	91	..	....	..	..	9	....	36	9	....	..	..	..	..	..

Table III—Plant Treated Water; Predominating Odor of Water

Month	Oily		Gasoline		Musty		Sewage		Medicinal		Aromatic		Woody		Vegetable		Misc.		No Odor	
	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold
January	7	37	0	4	37	4	15	7	11	0	0	0	11	0	4	0	4	0	11	48
February	13	44	0	0	74	17	0	4	0	0	0	0	0	0	0	0	9	0	4	22
March	0	48	0	0	84	4	0	4	4	0	4	12	0	0	0	0	0	0	8	24
April	4	30	0	4	80	25	0	0	0	0	0	0	0	0	4	0	0	0	12	41
May	4	28	0	0	75	11	3	14	7	0	0	0	0	0	0	0	0	0	11	47
June	0	0	0	0	91	30	0	26	0	0	0	0	0	0	0	0	5	0	4	44
July	0	0	0	0	78	27	0	0	0	0	0	0	0	0	0	0	0	0	22	73
August	0	3	0	0	81	19	0	0	0	0	0	0	6	0	0	0	0	0	13	78
September	0	0	0	0	100	62	0	0	0	0	0	0	0	5	0	0	0	9	0	24
October	0	12	0	0	96	48	0	0	0	0	0	0	0	0	0	0	0	0	4	40
November	0	0	0	8	92	72	8	8	0	0	0	0	0	0	0	0	0	0	4	12
December	20	90	0	5	75	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5

bid water, providing it has been coagulated and settled.

Rate of Flow.—Downward flow filters were operated at rates from 2 to 4 gal./sq. ft./min. Higher rates could have been employed but it was found that odor removal efficiency decreased as the rates increased so that for our own particular problem rates above 4 gal. were considered prohibitive. In a special experiment for chlorine removal only conducted in a bed of Darco 16 ft. deep, rates up to 135 gal./sq. ft./min. were employed for short periods.

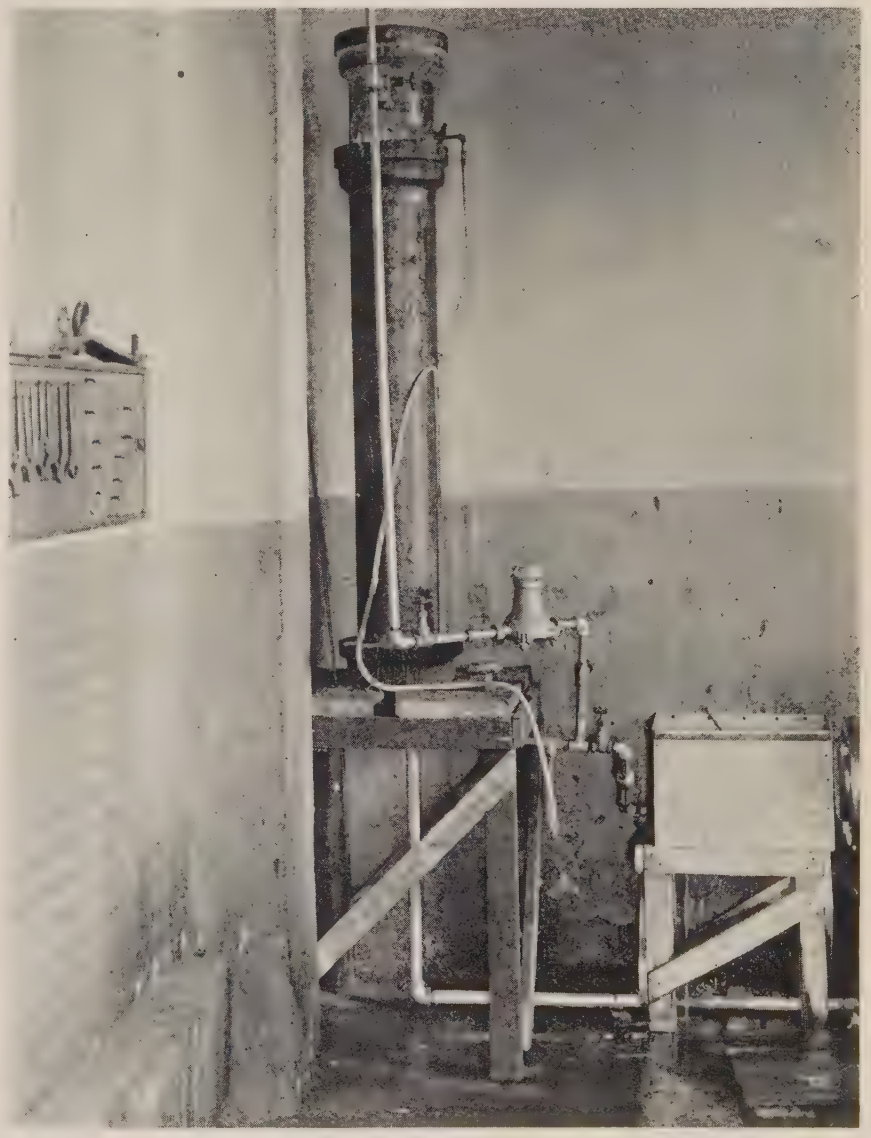
Upward flow filters were operated at rates from 2 to 3 gal./sq. ft./min. With the freeboard available in our filters the maximum upward rate without appreciable loss of material was 2 gal. for Nuchar and 3 gal. for Darco.

Loss of Head and Length of Runs.—Data on loss of head and length of runs is summarized in Table IV. Somewhat irregular figures were recorded on the same filter at different times and these features semed to depend to some extent on the arrangement of the particles of the bed after washing. In some instances the length of run was quite short when a new filter was first placed in service but after a few washings the run increased to normal probably because of loss of fine material on washing. Filter No. 6 operating on coagulated water behaved like a normal rapid sand filter as regards loss of head and length of run.

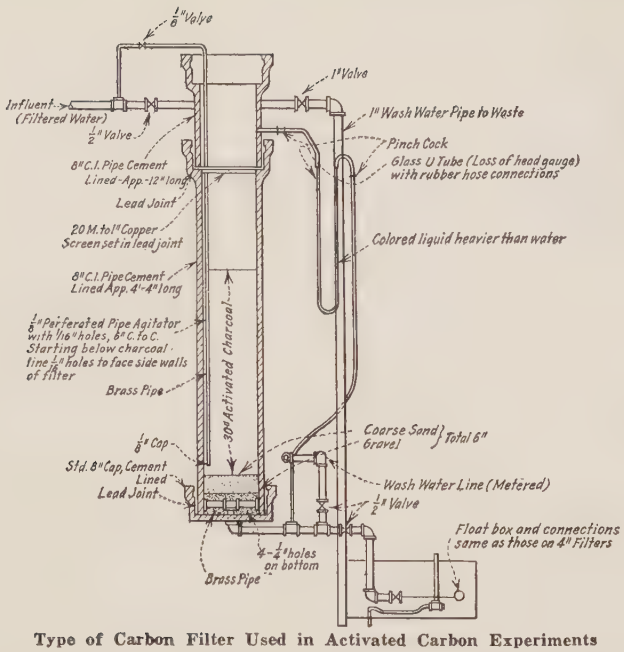
Washing.—Upward flow filters do not require washing under normal conditions. However, after about 5 months of operation some clogging was noted in Filters 7 and 8 and was found to be due to accumulations of material in the gravel. This condition was practically eliminated by alternate flooding and releasing the water in a downward direction. Similar accumulations gathered in the upper portion of the carbon on the downward flow units and resisted efforts to remove them with wash water. These accumulations may be attributed to iron from the pipe lines and possibly to particles of lime from the secondary lime treatment.

The first of the carbon filters were equipped with 20-mesh copper screens to hold the carbon down when washing. These screens were found to interfere with washing by preventing the expansion of material and were later removed. While the screens were in place a rate of wash of 15 gal./sq. ft./min. was used and this was the rate employed on the Minchar filters at all times. After the removal of the screens a gal./sq. ft./min. rate of wash was employed on all units except the Minchar.

Regeneration. — Experiments have demonstrated that when the carbon begins to lose its efficiency for removing odors it can be regenerated, at least partially, by the use of steam or hot air. Since steam under pressure was readily available it was used exclusively in the practical experiments under discussion. The method was simply to drain the filter and apply steam slowly into the under drains until the whole mass was heated to boiling temperature, where it was maintained until the steam rising from the top of the filter was relatively free from odor. The time required to accomplish this was from 20 to 30 minutes and in some cases a filter was steamed for two such periods with a normal wash between steamings. It was very interesting to stand above the filters while they were being steamed and to observe the odors which were driven off. During the earlier part of the process the lighter hydrocarbons and other volatile materials predominated later giving way to the odor of heavier oils and unpleas-



Experimental Filter Used in Activated Carbon Experiments



Type of Carbon Filter Used in Activated Carbon Experiments

ant organic material. The results indicate that the ability of the filter to remove odors is restored, to a great extent, by this treatment. It appears, however, that the period of effective operation may decrease after each regeneration and the presumption is that a point would ultimately be reached when nothing would be gained by further regeneration and the carbon would have to be removed and replaced or else reactivated in retorts or by some other method, if this is possible. The length of time before the material reaches a point where regeneration with steam is unsatisfactory cannot be stated definitely, but it probably depends on the material used, the water treated and the rate of filtration employed.

Practical Application of Carbon Filtration on a Large Scale.—A full discussion of the practical application of activated carbon on a large scale is beyond the scope of this paper.

Baylis has suggested that the carbon be placed in a specially designed compartment located in the clear well and that the sand filter effluent be passed upward through the carbon. This arrangement might prove advantageous for certain waters where the function of the carbon is to remove residual chlorine and small amounts of phenol or similar odorous compounds. Obviously this arrangement could not be readily adapted to regeneration in place with steam.

In those cases where it is desirable or necessary to employ carbon filtration on the site of an existing gravity type filtration plant the carbon could be placed in pressure filter units and inserted on the discharge side of the high duty pumps. In the case of an existing pressure filter plant the carbon pressure units could be placed in series following the sand units. Either downward or upward flow types might be used with this arrangement. The danger of particles of carbon being carried into the distribution system would be prevented with downward flow type by the layer of sand beneath the carbon. However it appears that this danger could be minimized and perhaps eliminated in the upward flow type by placing the outlet at a point sufficiently above the level of carbon in the filter.

In those cases where water is pumped from a filtration plant to an open storage reservoir before passing into the distribution system the carbon filter plant could be located at the reservoir. In this case the carbon units might be either open or pressure type, operated on either the upward or downward flow principle.

In any case, the carbon units should be so designed as to permit the application of steam through the under drains in sufficient quantity to maintain a temperature of 212° F. for a half hour or longer. A suitable vent should be provided on closed type units to permit the escape of vapors during regeneration. A steam generating plant of proper size and suitable wash water facilities would be required.

Table IV—Summary of Results for Loss of Head and Rate of Flow

Filter No.	Rate Gal./ sq. ft./ min.	Loss of Head Feet Initial	Loss of Head Feet Final	Length of Run in Days Between Washings Ave.	Max.	Min.	Material
1	2	0.20	3.5	48	78	26	Nuchar
2	4	0.57	6.8	28	29	26	Darco*
3	2	0.47	4.4	23	39	10	Nuchar
4	3**	1.10	3.2	26	42	10	Nuchar
5 (1st period)	2	1.10	4.8	3	6	0.3	Darco
5 (2nd period)	2	0.6	3.8	28	40	22	Darco
6 (settled water)	2	0.5	5.4	4	6	2	Minchar
7	2	0.9	....	Indeterminate			Nuchar
8	3	0.6	....	Indeterminate			Darco

* Preliminary run with Nuchar not included.
** Preliminary run at 4 gallon rate not included.

Summary.—During the year 1929 a number of experiments have been conducted on a river water containing objectionable odors with a view to producing a drinking water which would at all times be free from appreciable odor or taste.

In all except one experiment the raw water was purified by passage through a rapid sand filter plant before being applied to the carbon filters. In the remaining experiment coagulation basin effluent was applied.

Comparing the respective efficiencies of the different materials used for odor removal at a given rate of filtration, these experiments indicate that Darco is superior to either Nuchar or Minchar. The difference between the last two is not so marked but the advantage is definitely in favor of Nuchar.

The harder materials like Minchar, which also have a lower carbon content, have an advantage in that they can be used in place of sand with coagulated water. The softer carbons like Darco and Nuchar are not applicable to direct filtration of raw or coagulated water but should be used on waters from which turbidity and organic matter have been removed.

On the particular water studied in these experiments a rate of filtration of 2 gal./sq. ft./min. gave best results. Lower rates were not tried but might have given better results on Nuchar and Minchar. Higher rates tended toward a decrease in efficiency.

It is possible to operate carbon filters with either upward or downward flow. Where conditions are favorable upward flow is to be preferred because head losses are small and washing is practically eliminated. On the other hand our experiments indicate that odor removal is not as good with upward as with downward flow even though a thicker carbon bed is used.

Under the conditions of this experiment it appears that a 30 in. bed of Darco operating on purified water at a 2 gal. rate will remove appreciable odor for about one year without regeneration.

The passage of steam through beds of Darco or Nuchar so as to maintain a boiling temperature for about a half hour will remove a quantity of the substances which have been absorbed by the carbon. It is probable that this process does not amount to complete regeneration of the material and that ultimately the capacity of the carbon to remove odor and taste will become impaired to such an extent as to require its removal and replacement

with new or completely regenerated material.

Objectionable odors in water due to minute quantities of industrial waste can be removed by means of activated carbon. With the new and improved carbons which are being developed it is reasonable to anticipate that even better results will be secured in future than those reported in this paper.

The work described in this paper was carried out under the general direction of Mr. T. H. Wiggin, Chief Engineer, Public Works Engineering Corporation, and Mr. Robert Spurr Weston, of Weston & Sampson, Consulting Sanitary Engineer.

Acknowledgment—The foregoing is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

Progress of Research on Dams

American research into the problem of dams, one of the major issues of the World Power Conference in Berlin, is assembling a large body of scientifically determined facts which will be made available to engineers and government commissions in all parts of the world, it is announced by H. Hobart Porter, chairman of the Engineering Foundation and president of the American Water Works & Electric Co.

The decision of the International Large Dams Commission to become a subcommittee of the World Power Conference has opened the way to exchange between engineering bodies which will be a valuable factor in preventing disasters. Recent tests made in this country also indicate methods which will bring about important savings in the cost of great engineering projects.

In 1923 the Engineering Foundation began an investigation of arch dams. A concrete dam 60 ft. high was built in a canyon in the Sierra near Fresno, Calif., and subjected to a variety of experiments and precise measurements at a cost of more than $100,000.

To supplement this large-scale experiment, tests were made in the laboratories of Princeton University by Prof. George E. Beggs on models in celluloid of this Stevenson Creek Dam. The first model was a replica of the dam as built but only one-fortieth of its linear dimensions. Later, tests on two other celluloid models were made by Prof. Beggs, and these have only recently been completed. One of these models represents the Stevenson Creek Dam as if built to a height of 80 ft. and the other as if built to a height of 100 ft.

These recent tests on the additional celluloid models indicate that the Stevenson Creek Dam, with its thickness of only 2 ft. of concrete, excepting at its very bottom in the V of the canyon, would have stood if the reservoir had been filled with water to the top of the dam. The models have indicated the ways in which the forces are distributed throughout the dam and the ways in which it would bend under the pressure of water in the reservoir, disclosing the true mathematical nature of the structure.

These experiments have made available to engineers some carefully determined facts to replace many assumptions. The interesting question is raised as to whether it would be worth while to spend a large sum of money in building the existing experimental concrete dam to a height of 100 ft., installing expensive instruments and testing it as the present 60-ft. dam was tested. Some persons would like to see how the experimental concrete dam really would break if built high enough to give way under the pressure of the water. The committee is now considering his question.

The agreement between the results obtained on the dam and upon the first celluloid model was so close that there appears to be good justification for accepting other tests when properly made on other models of dams.

For a further check, tests were made with the co-operation of the Bureau of Reclamation under Commissioner Elwood Mead and Chief Engineer Raymond F. Walter of the Denver office; by John L. Savage, designing engineer; Ivan E. Houk, research engineer of the Bureau, and by Prof. H. J. Gilkey of the University of Colorado, with the assistance of Dr. Fredrik Vogt of Trondhjem, Norway. These tests were made in the laboratories of the University and corroborated the former results. Tests of other dams built or proposed by the Bureau of Reclamation were also made, and these results have been very thoroughly studied by the engineers conducting them and by others, especially Dr. H. M. Westergaard of the University of Illinois and Dr. Vogt.

To supplement these tests of large and small models, there are in progress field examinations of large dams built for practical use in Mexico, Arizona, California, Oregon, Washington and Montana.

The Engineering Foundation, as the agency of the national engineering societies, is also co-operating with a committee of the American Society of Civil Engineers interested in other types of dams. The Bureau of Reclamation is continuing its studies and other organizations are devoting attention to dams, so that a large body of scientifically determined facts may be available to engineers designing, building and maintaining dams in all parts of the world, and to regulatory commissions of government.

At the University of California, furthermore, there have been in progress for the last few years very precise tests on the concrete used in the Stevenson Creek Dam. By this research, Prof. Raymond E. Davis has brought out some interesting characteristics of the concrete used for many kinds of structures nowadays which were not previously understood. This is an important addition to the art of designing and building dams and other structures of concrete.

Prof. Charles D. Marx of Leland Stanford University is chairman of the Committee on Arch Dam Construction, Mr. Porter said, and Fred A. Noetzli of Los Angeles is secretary. Harry Hawgood is chairman of the sub-committee on the construction and test of the Stevenson Creek experimental dam, which was built under the general direction of H. W. Dennis, chief civil engineer of the Southern California Edison Company. The work was supervised by Prof. W. A. Slater, then of the Bureau of Standards and now in charge of the John Fritz laboratory at Lehigh University. Prof. Slater also conducted the thousands of tests on the Stevenson Creek Dam and prepared a large part of the report.

Water Waste to Be Reduced by New Building Code of New York City

The plumbing recommendations of the subcommittee on plumbing of the Merchants Association Committee of New York City which is preparing a new building code for the city contains a suggestion which if adopted will result in the saving every day of millions of gallons of water which now runs to waste in homes and office buildings.

John J. Dietz, Commissioner of Water Supply, of New York City, for several months has been carrying on an active campaign to prevent the unnecessary use or the waste of water. He recently made an inquiry, which disclosed that the close proximity of hot and cold water pipes in thousands of buildings is the cause of millions of gallons of waste. It has been a common practice to place the pipes so closely together that the cold water pipes absorb enough heat to make them warm or even hot. When users turn on the cold water tap they are obliged to let the water run for from thirty seconds to a minute before cold water is obtained. The aggregate loss of water is enormous and both Commissioner Dietz and Commissioner Brady of the Bureau of Buildings in Manhattan have asked the code revisers to correct the situation.

In devising the new code, the problem has been met by providing that where hot water supply systems are installed, the hot water riser shall be covered with approved insulating material unless the hot and cold water risers are at least 6 in. apart. It is figured that a hot water pipe 6 in. or farther away from a cold water pipe will not have material effect on the temperature of the latter.

Efficiency of Chlorination at Chicago

An Interesting Description of the Highly Organized Chlorination Control System of This City and the Results Obtained

By H. H. GERSTEIN

Sanitary Engineer, Division of Water Safety Control, Bureau of Engineering, City of Chicago

A STUDY of the data obtained during five years of chlorination in Chicago, Jan. 1, 1925, to Dec. 31, 1929, which includes the results of bacterial analyses of over 50,000 samples of raw chlorinated water, shows that Great Lakes water of widely varying pollution may be treated by chlorination alone to produce a safe drinking water which is well within the U. S. Treasury Department standard, providing that strict supervision is maintained over the treatment at all times.

Quality of Raw Water.—Chicago obtains its water supply from Lake Michigan through six intake cribs located along the lake front at distances varying from 2 to 4 miles from shore. The quality of the water at any one of these cribs, no matter how near or far from the sources of pollution, may vary within wide limits within a short period of time, from a practically sterile to a moderately or grossly polluted water, or vice versa. This condition is due to the fact that the pollution is carried by wind induced currents which vary with every change of wind direction. The most southerly intake—the Dunne Crib—being nearest to the highly polluted section of the lake off the Calumet industrial region, obviously receives the most polluted water. The quality of the water at the other intakes varies with the distance from shore and from the sources of pollution.

Table I is a summary of the frequency of occurrence of various degrees of pollution at the intakes. It will be noted that the frequency of the greater pollution is low. This, however, is no criterion of the difficulties encountered in the treatment of the water; the raw water may at any time, without warning, become highly polluted.

Figure 1 shows in chart form the percentage frequency of occurrence when the B coli content of the raw water at the various intakes was equal to or greater than 10, 100 and 1,000 B coli per 100 cc.

Chlorination Control.—Since treatment with chlorine is the only line of defense in protecting the quality of its public water supply, Chicago has

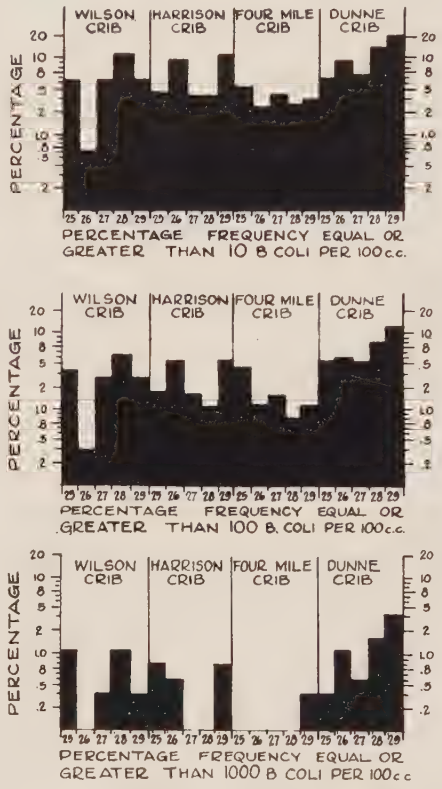


Fig. 1—Frequency of Occurrence of B coli Per 100 cc. (Phelphs), 1925-1929

of necessity developed a highly organized chlorination control system. The chlorine is applied at each of the 12 pumping stations at a point before the water reaches the suction of the pumps. In order to insure continuity of operation, all the chlorination equipment is in duplicate. A man is on duty at each pumping station at all times, whose only work consists of operating chlorination apparatus, performing control tests and keeping records of these tests. Control tests consist of hourly checks on the operation of the chlorinators by determining the loss of weight of the chlorine cylinders, and hourly orthotolidin tests for residual chlorine. During periods when the chlorine absorbing qualities of the water are on the increase, these tests are made as often as every 15 minutes. In addition, there are daily checks on operation by means of bacteriological analyses of samples of raw and chlorinated water, collected at each of the pumping stations, and from the distribution system; also independent daily checks are made of the chlorine battery scale weights and residual chlorine tests. The equipment is kept in first class condition at all times by frequent cleaning and servicing.

Special attention is paid to the meteorologic conditions, such as winds, rainfall and lake levels, all of which have great influence on the discharge of pollution into the lake, and the carrying of this pollution to the intakes. A study of these condtions makes it possible to forecast the pollution to be expected at the various intakes and to determine the minimum chlorine dosages which can be carried with safety at the various pumping stations. The residual chlorine test is considered the most important gauge of the effectiveness of chlorination. Since under ordinary conditions it is not practicable to make these tests oftener than once each hour, and since the quality of the water may change without the knowledge of the operator between these hourly tests, it is at present desirable to forecast the maximum pollution to be expected at each of the intakes and to regulate the dosages accordingly. It is endeavored to maintain at all times at least 1 to 2 lb. per million gallons of residual chlorine after a 10-minute contact. Under ordinary conditions the residual chlorine runs higher than this because of the factor of safety used to take care of sudden changes in chlorine absorption.

Table II is a summary of the average and maximum chlorine applied to the water from the various intakes. The average for all intakes for the period was 3.77 lb. m.g.; the Wilson and Harrison cribs averages of 3.39 lb. m.g. were the lowest; and that of the Dunne crib, 4.33 lb. m.g., was the highest. The maximum dosage for the period of 14 lb. m.g. was applied during 1927 to the Dunne crib water.

The high dosages were necessitated by the presence at times of chlorine absorbing substances in the water. At such periods the ordinary dosages of chlorine applied are entirely absorbed, leaving no residual chlorine to do the work of disinfection. It is then necessary to apply sufficient chlorine to satisfy the chlorine demand, plus an additional amount for residual chlorine. The chlorine absorbing substances may

Table I—Percentage Frequency of Occurrence of B coli in Raw Water at Crib Intakes; 1925-1929

Crib Intake	Year	Number of Sampling Days	Percentage Frequency of Occurrence, by Days, B coli per 100 cc. 0	2	4	6	8	10	100	1,000	10,000
Wilson	1925-29	1,826	45.3	26.2	12.0	7.4	3.7	2.6	2.2	.5	.11
Harrison	1925-29	1,825	47.3	21.3	12.7	7.6	4.3	3.8	2.6	.4	....
Two-Mile	1929	365	38.4	21.1	12.6	9.1	5.8	6.6	4.7	1.9	....
Four-Mile	1925-29	1,825	55.9	21.2	10.7	5.7	2.5	1.9	1.6	.05	....
Dunne	1925-29	1.825	45.7	18.3	10.6	7.1	5.7	5.5	5.2	1.3	.11
All cribs	1925-29	7,666	48.2	21.8	11.5	7.1	4.2	3.6	3.0	.6	.05

Table II—Chlorine Applied to Water from Each Crib Intake; 1925-1929

Crib Intake	Chlorine Applied (Lb. per 1,000,000 Gal.) 1925	1926	1927	1928	1929	1925-1929
Wilson—						
Average	2.98	3.56	3.37	3.29	3.64	3.39
Maximum	5.5	5.0	9.25	7.0	9.0	9.25
Harrison—						
Average	3.19	3.54	3.30	3.25	3.67	3 39
Maximum	4.5	5.0	4.25	6.0	8.0	8.0
Two-Mile—						
Average	.....	.....	.....	.....	4.08	.....
Maximum	.....	.....	.....	.....	10.0	.....
Four-Mile—						
Average	3.56	3.50	3.36	3.25	3.58	3.45
Maximum	5.5	5.0	4.5	4.5	6.0	6.0
Dunne—						
Average	4.07	4.27	4.33	4.27	4.56	4.33
Maximum	5.5	7.0	14.0	10.0	13.0	14.0
All cribs—						
Average	3.50	3.78	3.69	3.68	4.04	3.77
Maximum	5.5	7.0	14.0	10.0	13.0	14.0

Table III—Relation Between B coli Index of Raw and Chlorinated Water at Chicago; 1925-1929

Raw Water Average B coli per 100 cc.	Number Crib Days	Chlorinated Water Average B coli per 100 cc.	Number of Samples
0, 2, 4 Avg. .63	5,355	.042	30,498
6, 8, 10 Avg. 5.98	2,025	.067	12,367
100	233	.074	1,590
1,000	48	.187	353

be divided into two types, the first being industrial and sewage wastes which are discharged into the lake from the Calumet region. Recent tests have shown that the dilution of as little as one part of ammonia still liquor in 10,000 parts of lake water will increase the chlorine absorbing properties of the water materially. The second type of chlorine absorbing substances are the finely divided particles, organic and inorganic, which are thrown into suspension by prolonged, severe lake storms.

Efficiency of Chlorination.—The results of bacteriological analyses of the samples of raw and chlorinated water were studied for the purpose of determining the efficiency of chlorination as practiced in Chicago. These studies were made along the lines followed by Streeter* in his studies of the efficiency of Water Purification processes of plants on the Ohio River and Great Lakes.

The bacterial analyses were made in accordance with Standard Methods at the Chicago Health Department laboratories. The B coli index for routine records is calculated by McCrady's method of probable numbers, but in order to make the results presented in this paper comparable with similar studies, the B coli index has been calculated by the Phelp's method. The data may be taken to cover the results of five years of operation of a large number of individual chlorination plants; each of the various intakes can be considered to reecive water of different bacterial quality on the same day, and the water from each of the intakes is distributed to two or more pumping stations, at which it is chlorinated separately. For the purposes of this study, the results of bacterial analyses of the chlorinated water from all pumping stations supplied by a single intake are grouped together. A single sample from the first sampling point of each crib tunnel system was taken to represent the daily quality of the raw water at the intake. The results of analyses of samples collected from the Two-Mile Crib system were omitted for the years 1925 to 1928 because the water was prechlorated at the crib during this period and therefore no record of the bacterial quality of the raw water was available.

These data are divided into various groups, according to the degree of pollution of the raw water and the corresponding quality of the chlorinated water, and the averages of these groups are calculated, as shown in Table III. Figure 2, a chart which is plotted on a double logarithmic scale from the data in Table III, shows the relation between the B coli index of raw and chlorinated water. It may be readily seen that there is a distinct relationship between the quality of the raw and chlorinated water, the points plotted adhering very closely to the straight line for which an equation may be obtained. This relation is similar to that found by Streeter* and Wolman† in their studies of efficiencies of purification processes. The slope of the line plotted would indicate that with the method of chlorination practiced in Chicago, a raw water having an index of 5,000,000 B coli per 100 cc. may be treated to produce an effluent which will pass the U. S. Treasury Standard. No such efficiency can be attained in practice because of the fact that as the pollution becomes greater the chlorine absorbing substances in the water increases, making the maintenance of sufficient residual chlorine for disinfection increasingly difficult and requiring abnormally high dosages of chlorine. Even under present conditions it is difficult to maintain residual chlorine in the water during certain periods. It is only by strict supervision over chlorination, and high dosages at times, that the present efficiencies can be maintained.

The chlorinated water has at all times passed requirements of the U. S. Treasury Department standard for a safe water. Table IV is a summary showing how chlorinated water corresponding to various degrees of raw water pollution met these requirements.

Influence of Turbidity on Efficiency.—From the purpose of studying the effect of turbidity of the raw water on the efficiency of chlorination, the data is sub-divided into groups of similar turbidity, as shown in Table V. This data which is plotted in chart form in Fig. 3, shows strikingly that the efficiency of chlorination decreases with

*Public Health Bulletins Nos. 172 and 193—"Studies of Efficiency of Water Purification Processes"—H. W. Streeter.

†"Degree and Nature of Bacterial Removal"—Jour. A. W. W. A., September, 1918, by A. Wolman.

Table IV—Summary Showing How the Chlorinated Water Corresponding to Various Degrees of Raw Water Pollution Met the Different Requirements of the U. S. Treasury Department Standard for a Safe Drinking Water; 1925-1929

Raw Water Average B coli per 100 cc.	Raw Water Average B coli per 100 cc. Max. Allowed—1.0	Chlorinated Water Percentage of 10 cc. Portions Positive Max. Allowed—10%	Chlorinated Water Percentage of Samples Which Were 6 B coli per 100 cc. or More Max. Allowed—5%
0, 2, 4 Avg. .625	.042	.42	.15
6, 8, 10 Avg. 5.98	.067	.67	.25
100	.074	.74	.50
1,000	.187	1.87	.567

Table V—Influence of Turbidity on Relation Between B coli Index of Raw and Chlorinated Water at Chicago; 1925-1929

Raw Water Average B coli per 100 cc.	Raw Water Turbidity p.p.m.	Number Crib Days	Chlorinated Water Average B coli per 100 cc.	Chlorinated Water Number of Samples
0, 2 Avg. .65	0—9	3,391	.0368	18,473
.565	10—49	1,993	.0433	11,966
1.21	50 over	71	.158	450
4 5.92	0—9	1,168	.0442	7,110
6, 8 Avg. 6.06	10—49	779	.082	4,447
10 6.77	50 over	121	.146	723
	0—9	133	.070	973
100	10—49	69	.063	431
	50 over	31	.124	192
	0—9	21	.0835	168
1,000	10—49	12	.27	89
	50 over	15	.292	

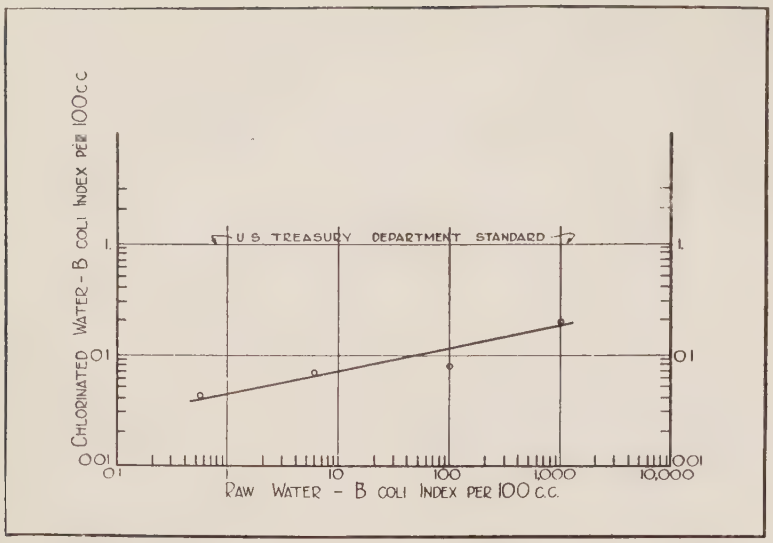


Fig. 2—Relation Between B coli Index of Raw and Chlorinated Water at Chicago, 1925-1929

increased turbidity. A small factor in this trend may be that with increase in turbidity there are also increases in chlorine absorptive properties, which make chlorination more difficult. This, however, accounts for only a small portion of the trend, because an increase in chlorine absorption due to this cause is not observed until the turbidity becomes quite high.

Future of Chlorination at Chicago.—During the last few years there has been an increasing trend in the pollution of the lake water off Chicago, mostly by wastes discharged from the Calumet region. The indications are that pollution will continue to increase, especially in light of the recent Supreme Court decision which ruled that diversion from Lake Michigan into the Drainage Canal should be progressively reduced in the next nine years. It is estimated that during 1929, 6,500,000,000 gal. of water having abnormal chlorine absorptive properties were pumped into the distribution system or approximately 1.7 per cent of the total yearly pumpage.

Production of a safe drinking water by chlorination alone will become increasingly difficult. The higher chlorine dosages required at times for effective disinfection will cause objectionable tastes and odors. This, coupled with the turbidity after each storm on the lake and the obnoxious algae tastes and odors, will make the water more and more unpalatable, until a time will come when the public will refuse to use it for drinking and domestic purposes. Such a condition would probably produce grave physiological effects on the health of the citizens of Chicago.

Tests have shown that filtration will easily produce a satisfactory water. Chicago must make a determined effort to install such plants as soon as possible.

Acknowledgment.—The foregoing is an abstract of a paper presented June 5 at the 50th annual convention of the American Water Works Association.

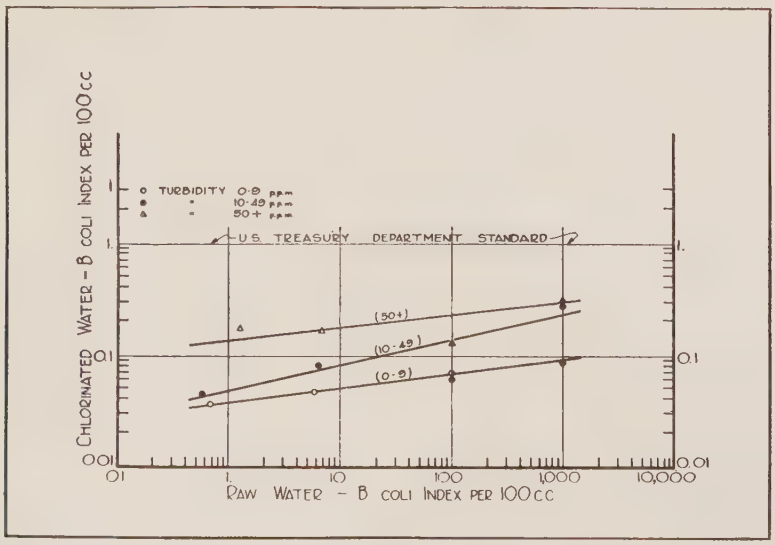


Fig. 3—Influence of Turbidity on Relation Between B coli Index of Raw and Chlorinated Water at Chicago, 1925-1929

Status of Sewage Treatment at Chicago

The status of the sewage treatment construction program of the Sanitary District of Chicago on June 1, 1930, was as follows, according to the semi-annual report of the district:

Completed Work as of June 1, 1930

Des Plaines River Project	$ 4,005,843.06
Calumet Project	19,375,028.09
North Side Project	35,889,832.75
West Side Project	30,278,128.22
Southwest Side Project	192,753.73
Miscellaneous plants and sewers	521,060.20
Chicago River Controlling Works	53,415.74
Total	$ 90,316.061.79

Future Work After June 1, 1930

Des Plaines River Project	$ 4,214,476.47
Calumet Project	20,274,893.93
North Side Project	5,964,678.68
West Side Project	64,234,806.57
Southwest Side Project	70,624,246.27
Miscellaneous plants and sewers	9,981,537.86
Chicago River Controlling Works	3,946,584.28
Total	$179,241,224.04

Further particulars on the progress of the program are given as follows in the report:

The estimated population of The Sanitary District of Chicago for the year 1930 is 3,710,000. The industrial wastes in the Sanitary District are estimated as equivalent to the sewage of 1,732,000 additional persons, hence the total population and industrial wastes equivalent amount to 5,442,000. This includes the Corn Products wastes, equivalent to the sewage of 432,000 persons which wastes have been greatly reduced as a result of certain experimental work initiated by the Sanitary District.

The sewage treatment construction accomplished, in compliance with the March 3, 1925, permit from the Secretary of War, up to Dec. 31, 1929, amounted to the equivalent (100 per cent) sewage treatment of 1,442,000 persons. This included an equivalent of 361,000 for the reduction accomplished on the Corn Products wastes and further included credit for construction accomplished on projects partially completed but not in actual service. For instance, the North Side Project was 96 per cent completed but actually operating to only 40 per cent capacity and the West Side Sedimentation Project was 48 per cent completed but not in operation. The total sewage treatment, referred to a basis of 100 per cent treatment on Dec. 21, 1929, was 366,000 based on actual population treated to which the addition of 361,000 for the work at the Corn Products plant gives a total equal to the 100 per cent treatment of the sewage of 727,000.

The 1930 total population and industrial wastes equivalent as above indicated are estimated as 5,442,000. Up to date the Sanitary District has assumed that sewage treatment could produce an annual average of 85 per cent purification. Hence so-called complete treatment for the total 1930 population and industrial wastes equivalent would equal the 100 per cent treatment of the sewage of 4,625,700, which is 85 per cent of 5,442,000.

Preammoniation of Filtered Water

Treatment at Filtration Works, Cleveland, O., by Means of Large Plant Installation of Ammonia Equipment

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THE use of ammonia for the prevention of objectionable tastes in drinking water which is disinfected with chlorine depends on the presumable formation of chloro-amines. The chemistry of the reactions involved when ammonia is applied to a natural water prior to chlorination is more or less obscure. It seems probable, however, that the formation of monochloro-amine and dichloro-amine are dependent upon the hydrogen-ion concentration of the water being treated. Probably in naturally alkaline waters a mixture of these two amines results. The combination of chlorine or hypochlorous ions with phenolic compounds, when the latter are present, to form chlorphenolic bodies producing foul tastes, is apparently prevented by the presence of the ammonia.

The theoretical ratio of NH_3 to Cl to form monochloro-amine is 1 to 4.2; and for the dichloro-amine it is 1 to 8.3. Under acid conditions a theoretical ratio of 1 to 3.12 produces NCl_3; and under alkaline conditions a theoretical ratio of 1 to 1.55 forms nitrogen gas. It is, therefore, probable that two great an excess of ammonia is liable to prevent the formation of chloro-amines, while an insufficient quantity may result in an excess of chlorine with the consequent formation of chlor-phenolic taste-producing compounds, should phenols be present. Within the range of pH values for most water supplies, there is probably formed a mixture of the monochloro- and dichloro-amines.

The disinfecting property of the chloro-amines is well established, and it is, therefore, desirable to provide if possible the optimum conditions for their production when depending upon them for bactericidal action. They have a somewhat slower action than does chlorine used alone, but they have a continuing inhibitory effect upon bacterial growths which is of great value for maintaining a water supply in good condition during its passage through pipe lines and reservoirs to the consumers. These facts have been confirmed in our experimental work.

Important Facts Established by Experimental Work.—The experimental work in Cleveland was primarily undertaken in order to find (1) An effective preventive of objectionable tastes produced by the occasional presence of small quantities of phenolic compounds, and (2) To prove the bactericidal properties of the process. For these purposes both laboratory and small plant scale experiments were made, and as a result a large amount of data was collected. It will only be possible in this paper to briefly indicate the important facts established in connection with the treatment of filtered Lake Erie water.

These points may be concisely stated as follows:

1. The application of anhydrous ammonia gas to a filtered water prior to its chlorination prevents objectionable tastes from chlor-phenolic compounds even when phenol is present in a concentration of one part per million.

2. Boiling the water thus treated does not develop the objectionable taste of chlor-phenolic compounds.

3. Chlorinous odors and tastes, which are not uncommon when chlorine is used alone, are also prevented.

4. The compounds formed by treating the water with ammonia before applying the chlorine are relatively more stable than those produced by adding chlorine only, as shown by "residual chlorine" tests, and by a prolonged inhibitory effect upon bacterial growths.

5. The process requires a small amount of inexpensive equipment, which may be used at existing water plants without modification of the latter, and is of low cost for operation and maintenance.

The Equipment.—Equipment for applying anhydrous ammonia gas to the filtered water before it is chlorinated was first installed in one of the city's filter plants in the fall of 1929. Operation of this equipment was started on Nov. 1, 1929, and has been continuous up to the present time. No ammonia gas control units for feeding the gas to the water being available at that time, manual control through an orifice by means of an ammonia needle valve was employed. A mercury manometer was used to measure the drop in pressure across the orifice, in addition to ammonia pressure gages placed before and after the orifice.

A large platform scale for determining by weight the amount of ammonia gas being used was placed in a room provided with steam heat. On the scale platform are laid five anhydrous ammonia gas cylinders, each of which contains 150 lb. of the gas. Flexible steel tubing is used to connect each cylinder with a valved manifold or header, on one end of which was placed an ammonia pressure gage. From the opposite end of the header a ⅜-in. iron pipe conveys the gas to the section containing the orifice plate, manometer and control needle valve.

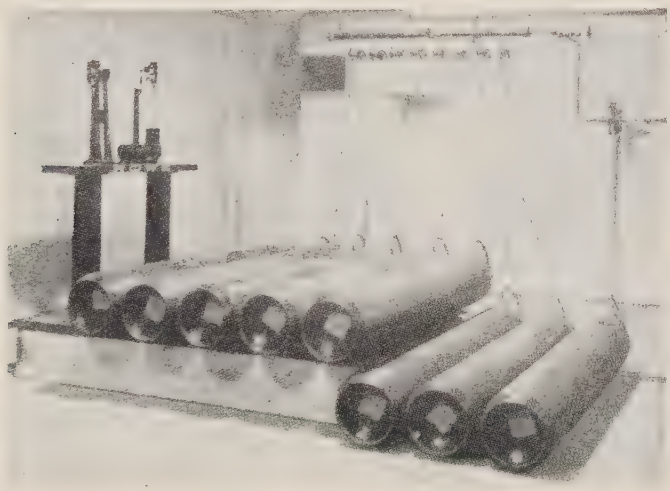
At this point the filtered water is conducted from the plant by two 54-in. diameter cast-iron pipe lines into a concrete twin conduit. Feeding the gas directly into these two pipe lines was not at first thought to be practicable, and, in consequence, it was decided to attempt to dissolve the gas in water and to discharge the ammonia water formed into the filtered water mains. After the gas passed the needle valve, therefore, it was conducted into an upright steel cylinder or absorption tank. Filtered water sprayed in at the top of the cylinder dissolved the gas and the ammonia water formed was drawn off continuously through a pipe at the bottom of the tank and conveyed by two branch lines of practically equal length to the filtered water mains. Within two months after starting this apparatus, the 1½-in. pipe lines which had been conveying the strong ammonia water to the filtered water mains were found to be clogged by an incrustation of calcium and magnesium carbonates. In consequence, the pipes were partially cleaned out, the water spray in the absorption chamber discontinued and the ammonia gas fed directly to the filtered water in the two mains.

The ammoniated water flows a distance of about 900 ft. before the chlorine is applied in a gate house opposite the entrance to the two basins of the filtered water reservoir. This reservoir has a capacity of approximately 20 million gallons and represents on an average about 25 per cent of the daily output of the filter plant. From this reservoir the water flows to the pumping station, where it is pumped directly into the distribution system. The foregoing facts are mentioned to show the mixing and detention periods which exist under average conditions at this plant after the application of the ammonia and chlorine.

A mercury ammonia gas control valve unit has been developed for the equipment at this plant but has not as yet been installed. In spite of the usual difficulties involved in adapting a new process to an existing plant with untried equipment, the application of the gas has been unusually uniform and the results obtained satisfactory.

Ammonia Gas Unit.—At the other city filter plant a Pardee ammonia gas control unit was installed, together with the necessary platform scale, manifold, piping, cut-off and control valves. This

equipment has been in continuous use since Jan. 4, 1930, and has proved to be accurate and easily operated. At this plant conditions were such that the ammonia gas had to be applied at four points, and only a short distance upstream from the point where the chlorine was added. The filtered water is collected from four effluent galleries or reservoirs under each quarter of the filter plant. From these four reservoirs it is conveyed by four 48-in. diameter pipe lines to a concrete conduit divided into two parts by a central partition. The ammonia gas is brought from the control unit on the floor above the conduit to a central point, from which four approximately equal lengths of ½-in. iron pipe permit the gas to be discharged into the four 48-in. mains.



Ammonia Gas Control Unit, Scales and Manifold at Baldwin Filtration Plant, Cleveland, O.

The chlorine from the chlorine machines is charged through a grid into the ammoniated filtered water at the end of the collecting conduit. The treated water then passes into a small gate chamber and from thence through four large gates to two basins of a large filtered water reservoir, holding 135 million gallons. This reservoir holds about 1½ times the present output of the plant.

The ratios of ammonia to chlorine applied at the two filter plants have been purposely varied from time to time. Two pounds of anhydrous ammonia gas to 3 or 3½ lb. of chlorine per million gallons have been used at one plant, while at the other plant the quantities have varied from 1 lb. of ammonia to 2 lb. of chlorine or 1 lb. of ammonia to 3 or 3½ lb. of chlorine per million gallons of filtered water. At both plants up to the present time of writing, there have been used 27,132 lb. of anhydrous ammonia gas. This represents at one plant 1.8 lb. of ammonia gas for each million gallons of filtered water, and at the other plant 0.96 lb. of ammonia per million gallons of water. At both plants about 235 lb. of ammonia gas are applied daily to the filtered water.

Results.—The results obtained from the use of ammonia in these two large filter plants have confirmed our experimental work. No tastes from chlor-phenolic compounds have been noted in the public water supply during the period the ammonia has been used. It is, of course, possible that no phenolic compounds contaminated the water supply during this period; but if they did the addition of the ammonia has effectively prevented them from uniting with the chlorine to produce foul tastes.

During the colder portions of the year, when the temperature of the water is the lowest, the residual chlorine is always the highest when using chlorine only for disinfection. Hence chlorinous tastes are more likely to be noted than when the water is warmer and the reaction between the chlorine and the water and its constituents more rapid. There has been an entire absence of these chlorinous tastes since using ammonia, although the apparent quantities of residual chlorine have been always higher as shown by the orthotolidine tests. The explanation for this fact is not apparent, but there is no doubt that the water has had a more pleasing taste since using ammonia as evidenced by statements of consumers.

The bactericidal efficiency of this process of disinfection has been carefully studied. Examinations of samples of water from widely separated points in the distribution system for their bacterial content have shown with few exceptions a water of as high a quality, if not higher, than when chlorine alone was used. Eight series of samples, which have been collected during the past six months, covered all of the various pressure service of the metropolitan district supplied with water from the Cleveland plants.

During the last three weeks in December, 1929, 147 samples of water in four series were taken on both the east and west sides of the district. The eastern portion of this area was supplied with water from the filter plant in which chlorine only was used, and the western portion by the filter plant in which both ammonia and chlorine were being used. This afforded an opportunity of comparing the effect of the two different methods of disinfection at the same time.

The average bacterial count both at 20° C. and 37° C. was 2 per cc. for samples of water which had been chlorinated only, and 0 and 0.5 per cc., respectively, for samples of water which had been treated with both ammonia and chlorine. No B. coli were found in any of the samples from either plant. The average residual chlorine for the chlorinated water was 0.013 p.p.m., and for the ammoniated and chlorinated water 0.16 p.p.m.

Four more series of samples (167 samples in all) were taken on both sides of the metropolitan district after the second filter plant had begun to apply ammonia with the chlorine. All samples gave an average bacterial count of one or less per cc. when incubated at either 20° or 37° C.; and no B. coli were found in any sample. The average residual chlorine was 0.2 p.p.m. The temperature of the water ranged between 5° and 8° C.

These results are ample evidence of the efficiency of the process when treating approximately 175 millions of gallons of water daily. They confirm our original experimental work and fully justify its adoption for Cleveland conditions.

Advantages of Process Summarized.—The advantages of the process may be briefly summarized as follows:

1. No chlor-phenolic tastes have been noted since beginning the application of the ammonia prior to chlorination.
2. Chlorinous tastes from residual chlorine have been eliminated.
3. The taste of the water is more acceptable than ever before, and no complaints from consumers have been received.
4. The bacterial efficiency of the process is as high, if not higher than when chlorine only is used.
5. The prolonged inhibitory effect on bacterial growths is of great value in maintaining a water in its highest state of purity throughout an extensive distribution system.
6. The cost of the equipment for applying ammonia is merely nominal, and may be readily adapted to any existing water plant. The cost of operation for the ammonia is low, and will not exceed $0.30 per million gallons of water treated, if the ammonia is purchased at $0.15 per lb.

Acknowledgment.—The foregoing is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
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Mixing Basins—Time of Mixing

THAT part of the filtration plant where the chemicals, which are used to coagulate the water, are applied, and where the mixing with the water and the reaction takes place is called the "mixing basin" or "mixing chamber." Such names as "reaction chamber," "coagulating chamber," "mixing and reaction chamber," "mixing channels," etc., also have been used to describe this part of the plant in some of the articles on filtration. The term "mixing basin" has become fairly well fixed in our minds and appears to be more appropriate than any of the other names with the possible exception of "mixing chamber." It is evident if the mixing is done in a conduit leading the water from one place to another that "mixing conduit" would be more appropriate. It is suggested that "mixing basin" be used for all cases where such a name would be appropriate, and that other names be used only where it is not appropriate to call the part where the mixing is done a basin.

The function of the mixing basin is to distribute the chemicals uniformly throughout the water and to keep the water in motion at velocity that prevents settlement of the flocculated matter.

This discussion will be limited largely to the time of mixing, with brief mention of the violence of agitation in the mixing basin. The design of mixing basins will be discussed in a later issue. The great variation in the time of mixing in use at filtration plants throughout the country indicates wide differences of opinion amongst designing engineers as to the most desirable mixing time. The writer is of the opinion that there has been more guesswork in the design of mixing basins than any other part of the plant; and perhaps justly so, for the results from different plants, or even at different times in the same plant indicate variable mixing times as being desirable.

Mixing Time Varies Widely in Existing Plants.—Mixing periods in filtration plants throughout the country will be found varying from about 3 minutes to about 90 minutes, with the majority of the basins having a mixing period of from 10 to 30 minutes. The tendency is towards a longer mixing time, and most of the newer plants provide for about 30 to 60 minutes mixing time. Different characters of water and other conditions make it desirable to use variable mixing times, but surely there should not be the wide differences that are found in the various plants.

Factors Influencing the Time of Floc Formation.—The factors that influence the time of floc formation are:

Quantity of coagulant used.
Time of mixing.
Temperature.
Violence of agitation.
Character of water.

Quantity of Chemicals.—It should be evident that the greatest factor influencing the time at which a good flocculation will form is the quantity of coagulation used. This is assuming that the alkalinity and pH are favorable for the formation of a good flocculation. The minimum quantity of chemicals necessary to coagulate the water to the extent that it will filter clear requires the longest period of mixing or stirring. A certain water with a turbidity of 10, treated with 6 parts per million of aluminum sulfate, may require 60 minutes mixing time to produce a good flocculation when the temperature is near the freezing point. If 12 parts per million of the coagulant are used, the time to produce a good flocculation may be only about 30 minutes. Three times the minimum quantity of coagulant will require a still shorter period. We might produce within 3 to 4 minutes time, with great excess of coagulant, flocculated particles as large as will be produced within 30 minutes mixing when the minimum quantity of coagulant necessary for good coagulation is used. It is largely this factor that enables the various filter plant operators throughout the country to get fairly good results when the mixing time in the plant is short.

If the turbidity of the water is 500, it might require 40 parts per million or more of aluminum sulfate to coagulate it to the extent that it will filter clear. With a temperature near the freezing point, 20 minutes mixing might produce a good flocculation when the minimum quantity of coagulant is used. In other words, water with high turbidity requiring considerable quantity of coagulant does not require quite as long a mixing period to produce a good flocculation as the same water low in turbidity.

The procedure now being followed in most filtration plants is to add sufficient coagulant to produce the desired flocculation for the particular mixing basin. The desired flocculation may vary with the length of settling after coagulation, for it is evident that a very long period of settling will produce as good clarification of the water with imperfect flocculation as a short period with perfect flocculation. When the period of mixing is short, very likely in most such plants the amount of coagulant added to the water is in excess of what would be necessary if there was a longer period of mixing. In some plants the mixing basin or mixing device produces maximum or nearly maximum efficiency, but all such plants have a fairly long period of mixing. Whatever amount of coagulant is necessary to bring the water to a condition where it can be handled without difficulty by the filters, is the amount that should be used.

Effect of Temperature.—At one time temperature was thought to have considerable influence on the quantity of coagulant necessary to use. Now it is known that its main effect is in delaying the formation of the flocculation. In such plants as have too short a period of mixing, more coagulant for a given turbidity may be required when the water is cold than when it is near the maximum temperature. This is what has given the impression to many that the lower temperature requires more coagulant. It does, if the mixing period is not long enough for the colder water. If the same quantities of coagulant are added to two samples of water from the same source, one at 1° C. and the other at 20°, the water at 20° very likely will form a good coagulation in from one-third to one-half the time of stirring as is required for the lower temperature. It seems that the differences in the time of stirring are wider when the turbidity is low and small quantities of coagulant are necessary than with higher temperatures.

The writer has not been able to detect any material difference in the

quantity of coagulant necessary to clarify water at different temperatures, providing longer periods of mixing are used for the colder waters. The fact that there are several other things that may influence the quantity of coagulant necessary for good clarification of the water, makes it difficult to take plant records and show the effect of temperature. The writer formed the opinion after observing several years' operating records at Baltimore, where there is fairly good mixing, that less coagulant was required in the colder months than in the summer months. This probably did not apply for fairly turbid water. The same thing seems to hold for the Lake Michigan water at Chicago. There no doubt are many cases throughout the country where more coagulant has to be used in the winter months for the same turbidity than in the summer months, even where there is a long period of mixing, but the cause is believed to be due to something other than temperature. It is believed that the real cause in most instances is the presence of suspended matter in an extremely finely divided state. Just why there should be more of this extremely finely divided suspended matter in the summer months is not known, and it may be that this is the case for only a few waters. At any rate we will find the plant records in some plants indicating that more coagulant is necessary for a given turbidity in the winter months, and others indicating that less is needed.

Character of the Suspended Matter.—Everyone is aware that the character of the suspended matter materially influences the quantity of coagulant. If one should plot the points of coagulant required against turbidity, for a filtration plant where there is good mixing and close supervision to see that an excess of coagulant is not used, the points would cover a range of chemicals necessary for a given turbidity in which the maximum is more than twice the minimum for any given temperature. Now the turbidity and the temperature are factors that we have to take as they are in the water, so this leaves only two things that may be varied by the designer and the operator of a filtration plant. These are time of mixing and quantity of coagulant. The designer usually sets the time of mixing, and the operator sets the quantity of coagulant. The kind of coagulant, of course, should be taken into consideration, but this is assuming the most suitable coagulant has been determined.

The extremely finely divided suspended matter is more difficult to entrap by the coagulant than the coarser particles. Some are of the opinion that the electrical charge on the particles has great influence on the ease with which it is coagulated. For extremely finely divided particles this may be the case, but for most of the suspended matter occurring in water the charge has little influence.

Filter Operator Is Limited in What He May Do.—After a plant has been constructed about the only thing the filter operator can do is to vary the quantity of coagulant. It is not so much to the operators as to the designing engineers that the writer wished to direct certain remarks. The skillful operator will do the best he can with a particular layout, but errors in design are not his fault.

If the poorly designed mixing basins were confined to those designed by engineers of limited experience it would not be so serious a reflection upon the profession, but some of the poorest mixing basins have been designed by the leading filtration engineers. It indicates that mixing basin design in the past has been largely a matter of choice or opinion, and that there are not many specific and convincing data on this subject. As the present article is limited largely to time of mixing, the design will be discussed in a later issue.

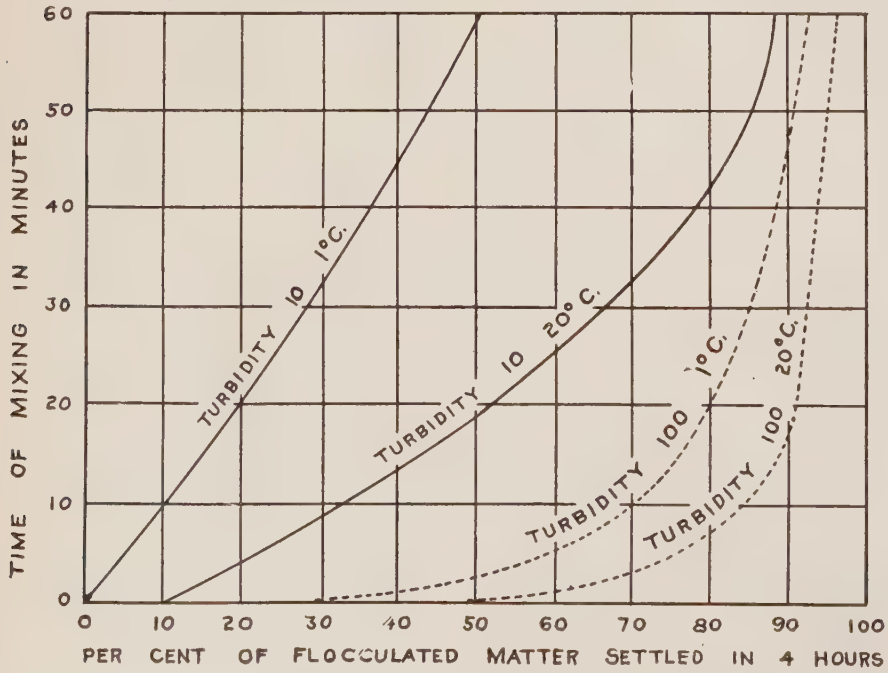


Fig. 1—Relation Between Time of Mixing and Rate of Settling

Time of Mixing.—Due to the fact that the water in a filtration plant is never still, the period of mixing in its broadest sense may be stated as being the time from the addition of the coagulant until the water reaches the filters. As used in the literature on filtration, and as used in this article, it is intended to define that part of the plant where the coagulant is added and there the water is kept in motion at a velocity sufficiently great to prevent settling of the flocculated matter.

It should be evident that coagulation and flocculation will eventually take place in settling basins with very long periods of settling, even if there is no mixing basin, for there is a continuous though slow motion of the water in such basins. The formation of the flocculation is very slow in settling basins, and it is usually economy to make the flocculation complete in basins designed for that purpose. The mixing basin should be responsible for the flocculation, and the settling basin should be limited to the function of settling out the flocculated matter. If it takes 60 to 90 minutes mixing to produce a good flocculation during the worst conditions of the water, then the mixing basin should be designed for this time unless such periods are of very short duration and additional coagulant may be used more cheaply than providing a longer period of mixing.

The trouble with the mixing basin in many filtration plants is that they are warm weather mixing basins, and are not adequate for water at a temperature near the freezing point. As a result, many filtration plants are overtaxed in the colder months and are not capable of producing perfect water all the time. Why not give more consideration to cold weather conditions? A basin designed for the water at its minimum temperature certainly would not be inefficient for warmer water, though it may have considerably longer mixing time for the warm water than is necessary.

The value of prolonged mixing is to provide more rapid sedimentation of the flocculated matter. Where the water temperature goes below about 5° C., most filter beds will not handle very much flocculated matter without danger of some of it passing the beds. Usually it is desirable to settle to the extent that the flocculated turbidity is below about 10 during the colder months, and the writer believes it is desirable to settle to 5 or even less for most waters where the temperature goes nearly to the freezing point.

It is not possible to discuss the time of mixing without giving some consideration to settling, for the main purpose of the mixing basin other than to

distribute the chemicals uniformly throughout the water is to prepare the water for the settling basins. The curves in Fig. 1 show the relation between the time of mixing and rate of settling at both 1° and 20° C. for turbidities of 10 and 100. Percentage of flocculated matter settled out may not be a very good method of expressing the results, for 50 per cent settling with a flocculated turbidity of 10 leaves no more flocculated matter in the water than 95 per cent settling for a turbidity of 100.

Long Periods of Mixing Give Best Settling Results.—If it is desirable to reduce the flocculated turbidity of a certain water at 1° C. to 5 within a period of 4 hours settling, it is shown that about 60 minutes mixing in a good mixing basin is necessary for the particular water on which the tests were made. This is based upon using the minimum quantity of coagulant necessary to clarify the water. No one should expect to get points that follow the curves exactly. They were drawn from a number of points obtained from plant results. The points varied widely, in fact, so widely as to make one hesitate to show the results by a curve. The curves are about an average of what is being accomplished in well operated plants. One reason for wide variations in settling results is that most filtration plants do not operate on the minimum coagulant necessary to produce clarification, but use a slight to considerable excess most of the time.

Fig. 2 shows the rate of settling for 5 and for 60 minutes mixing time. If a flocculated turbidity of 10 is desired, it is evident from the curves that a mixing time greater than 5 minutes is essential, unless there is a very long period of settling. The same remarks in regards to wide variations from the curves in Fig. 1 also hold for the curves in Fig. 2. The curves shown are about an average of what to expect when the water is near the freezing point. They also are based on the use of a coagulant only. Hard waters that are partially softened in the process by the production of a precipitate of calcium carbonate settle the flocculated turbidity much faster. The writer has found no difficulty in reducing the flocculated turbidity of a partially settled water, where lime was used for the softening, from 50 to 2 within an hour after a mixing period of about 60 minutes. Should the flocculated turbidity have been 500 it probably would have been reduced to this same low figure within approximately one hour.

It Is Economy to Use a Fairly Long Period of Mixing.—The writer can conceive of very few conditions where it would be economy to have a mixing period less than 30 minutes. In most instances it is economy to have a mixing time of from 45 to 60 minutes for aluminum sulfate, ferric chloride, and chlorinated iron; and from 60 to 90 minutes for ferrous sulfate and lime, and for softening processes where calcium carbonate is precipitated. About the only exception to the necessity for these long periods of mixing to produce good results is where an excess of coagulant is used for some purpose other than clarification. The writer has been told that one of our larger cities uses an excess of coagulant most of the time so as to get better bacterial removal. This is all right, but plants that care to use only the minimum coagulant should not use this plant as a guide for determining their mixing time.

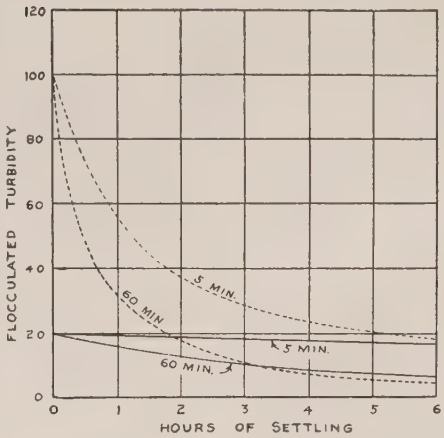


Fig. 2—Effect of Time of Mixing on Settling Rate

The writer has performed a number of laboratory experiments on varying the time of mixing. It is usually possible to bring about good flocculation in the laboratory with a stirring machine within 50 to 70 per cent of the time necessary to produce equal flocculation in a well designed plant mixing basin. The settling rate in beakers also is faster than in a plant settling basin. One hour in a beaker usually produces better clarification than 4 hours in a settling basin. Table I is typical of what one might expect for stirring experiments in the laboratory when the turbidity is very low and when the temperature is near 20° C. The raw water turbidity was 3.0, and when treated with 8 parts per million of aluminum sulfate the flocculated turbidity was 4.0.

Eight parts per million of aluminum sulfate was an excess of coagulant, but about what is being used in many filtration plants under similar conditions of turbidity and temperature. The minimum coagulant to clarify this water by filtration was 5 parts per million. Table II shows the settling results for the minimum coagulant.

Table I indicates that 20 minutes stirring with the laboratory stirrer would be about the economical time. This 20 minutes would be equal to about 30 to 35 minutes mixing in a plant mixing basin. If the water had been near the freezing point instead of room temperature it would have required a longer time to produce a flocculation that settled as rapidly as that for Table I, perhaps 50 to 60 minutes mixing in plant mixing basin would have been about the economical time. Table II indicates that with the minimum coagulant not much setting need be expected within 5 to 6 hours.

Table III gives the settling rate for various periods of stirring with a laboratory stirring machine when the raw water turbidity was 75.

Table III indicates the economical mixing time for a laboratory stirrer to produce a rapidly settling flocculation to be about 15 minutes when the turbidity is 75 and the temperature about 16° C. This would mean about 25 to 30 minutes in a plant mixing basin for the same conditions. With this same turbidity, and a temperature near the freezing point, the economical mixing time for a filtration plant would be about 35 to 45 minutes. Table III shows greater settling efficiencies than are shown by the curves in Fig. 1, but the curves are based on plant results. The laboratory tests were run in 2-liter beakers with a stirrer having two blades ½ in. wide and 1½ in. long. The stirrers were run at a velocity of approximately 1.0 ft. per second for the tip end of the blades. This seemed to impart nearly the same velocity to the water as the speed of the end of the blades.

Settling Rates Vary Widely in Filtration Plants.—Looking over the monthly report of a large filtration plant for the month of January when the water temperature was near the freezing point, the turbidity of the raw water averaged 8 and the settled water 2.5. The plant had a mixing time of about 40 minutes and a settling time of about 4 hours. This would give a point considerably off the curve shown in Fig. 1 for 40 minutes mixing, indicating the curve is not very accurate.

Table I—Settling Rates for Various Periods of Mixing

8.0 parts per million of aluminum sulfate used. Raw water turbidity, 3.0. Flocculated turbidity. 4.0.

Time Stirred in Minutes	Turbidity After Standing in Beakers 1 Hour	3 Hours
0	4.0	3.5
5	3.8	2.8
10	3.2	2.0
15	1.8	1.4
20	.7	.3
30	.4	.2
40	.2	.1

Table II—Settling Rates for Various Periods of Mixing When the Minimum Quantity of Coagulant Is Used

Raw water turbidity, 3.0. Flocculated turbidity, 3.5. 5.0 parts per million of coagulant used.

Time Stirred in Minutes	Turbidity After Standing in Beakers 1 Hour	18 Hours
5	3.5	1.3
10	3.0	1.1
15	2.5	1.0
20	2.2	1.0
30	1.8	.9
40	1.5	.8

Table III—Settling Rate for Various Periods of Mixing With Turbidity of 75

Water treated with 13 parts per million of aluminum sulfate. Flocculated turbidity, 76. Temperature, 16° C.

Time Stirred in Minutes	Turbidity After Standing in Beakers 30 Minutes	1 Hour	3 Hours
0	75.0	74.0	54.0
5	47.0	33.0	24.0
10	11.5	7.5	4.5
15	4.0	3.2	2.4
20	1.7	1.7	1.2
30	.7	.7	.6
40	.6	.5	.5

It is admitted that the curve is not accurate for some waters. In this particular case, 11 parts per million of aluminum sulfate were used to coagulate the water. Under most conditions 6 to 7 parts would have been enough, therefore the main cause for the rapid settling probably was due to the use of an excess of coagulant.

Very likely it was desirable to get good settling in this plant to prevent flocculated matter passing the filters. There is no criticism for using an excess of coagulant to produce better settling so as to produce a better filter effluent; it is the thing that should be done. This is one of the reasons why many plants will give results that vary widely from the curves shown in Figs. 1 and 2. In the particular instance mentioned the water may have contained a small amount of extremely finely divided particles that required a larger amount of coagulant than otherwise would have been necessary. The writer has treated water in which the average quantity of coagulant usually applied would give very good flocculation, but when the water was filtered it would have a turbidity of 0.5 to 1.0. To reduce this to the desired standard of 0.2, it would require from 25 to 75 per cent excess of coagulant. This excess, of course, gave a rapid settling flocculation. Just because a plant is using considerable excess of coagulant over what other plants for similar turbidities are using does not mean that the plant is inefficient, but in most instances it is.

Violence of Agitation.—There is every indication that a velocity of 1.0 to 1.3 ft. per second, now extensively used in mixing basin design, produces about the desired violence of agitation in baffled basins. The more rapid the velocity of water, up to a certain point, the quicker it will flocculate. It usually is economy to use velocities somewhere near the maximum which will allow good flocculation. It has not been possible to determine accurately the maximum stirring velocities of the laboratory stirrers that will produce the quickest settling flocculation. There are indications that it is near 1.0 to 1.3 ft. per second for the ends of the blades. Two feet per second is too high. When experiments were run using this speed for the stirrers the flocculated particles would form to a certain size and then get no larger. This size was much less than what is essential for rapid settling. One and one-half feet per second velocity for the ends of the blades did not seem to produce a flocculation that settled as quickly as 1.0 ft. for the particular water tested, but the results were so near there were practically no difference.

These experiments were made with aluminum sulfate. Other chemicals may give slightly different results. Another set of experiments indicated that there was no advantage in using higher velocities in the first part of the mixing, providing the last 10 to 15 minutes stirring was at a rate of 1 ft. per second or slightly less. In plant basins it may be found slightly advantageous to start the mixing with fairly violent agitation, but the advantage is so little it does not justify the expenditure of much additional force for the extra agitation. If a more violent agitation is given immediately after application of the coagulant, the writer would suggest that it be for a period not greater than 4 to 5 minutes, for it very likely has no advantage beyond this time.

With straight conduits and circular basins where there are no abrupt changes in the direction of flow, greater velocities probably are desirable. It is believed that 2 to 3 ft. per second may be used without detriment under such conditions, but in these cases it probably is economy to use velocities not in excess of 1.5 to 2.0 ft. per second.

Why Not Guess on the Safe Side?—If the matter of mixing time is largely a guess on the part of the designer, why not guess on the safe side and give the operator a plant that will enable him to produce good results under the worst conditions of the water? The writer would suggest that no filtration plant be designed with a mixing time less than 30 minutes, except under some very unusual condition where it has been demonstrated conclusively that a shorter period gave the more economical results.

Central Clearing House Aids Water Service

The Central Service Bureau established by the Hackensack Water Co. at its general offices in Weehawken, N. J., has become a huge clearing house for improving the operation and administration of the water supply system of Bergen and North Hudson Counties.

It now functions largely as an instrument of inspection and control, enabling the company organization to locate defects in service, to classify and to study these defects, and to take immediate steps to apply the appropriate remedy.

The bureau began operations on Oct. 1, 1928, with the expressed purpose of affording contact, direct and continuous, with consumers throughout the 24 hours of the day. Its development has been such that it now acts as an agency through which inter-departmental practice of the company may be carried on, and through which the municipal officials and the water users in the 51 towns and cities served by the company may immediately register their needs.

It is a receiving station to which any consumer at any hour of the day or night may report any untoward tendencies in the water system and be assured of speedy action. It is a repository of suggestions for social and technical betterment from individual citizens, from officials of cities, and from civic groups, as well as for the exchange of operating and administrative information among the departments of the company.

Co-ordination of public needs and company policy is thus accomplished. The company officials can at all times effectively check developments throughout the system, the operations of the Central Service Bureau quickly and clearly revealing strength or weakness at any point. In short, according to company officials, the bureau provides a method of vigilance by which standards of water service can be consistently improved. To it the entire staff of the company reports, and to it the public has ready access.

The second 5,000 reports received by the bureau have been recently tabulated by the company. Of these, 842 had to do with house pressure conditions, mostly originating in old plumbing; 700 with leaks in service pipes between curb lines, and 419 with leaks between curb lines and meters.

In response to requests, 595 curb boxes or curb valves were adjusted or repaired. Removal of check valves as a result of noises in house plumbing or other causes was requested by 553 customers.

The largest number of communications originated in localities where the majority of services have been installed for many years. From Union City came 570; from North Bergen, 473; from Englewood, 387; from West New York, 383; from Hackensack, 283; and from Fort Lee, 199.

The situations indicated by these communications, many of which were forwarded by municipal departments, were investigated by the company, and classified, the result being the creation of a vast and growing fund of knowledge on the operation of the water system.

When communications bearing upon service are received from any source they are recorded on special forms prepared for the purpose, and routed to the departments to which they relate. After investigation, they are reviewed by the company's hydraulic engineer, whose recommendations or suggestions are embodied in letters of reply. The bulk of the communications, by telephone or by letter, come directly to the Central Service Bureau in Weehawken. This practice the company encourages. Many customers report to the district offices, in charge of supervisors, who transmit the information to the Bureau.

Careful records are kept of how reports are investigated, of what action is taken thereon, and by whom, so that in time they will comprise the history of every service number. Daily happenings throughout the water company's territory are classified, making it possible, through observation extended over a long period, to identify fundamental differences common to a certain section. In this way, the requirements of special areas are anticipated.

Manipulation of pH in Water Purification

Experiences at Filtration Plant of the Department of Water, Light and Power of the City of Springfield, Illinois

By CHARLES H. SPAULDING

Chemist and Superintendent Water Purification, Springfield, Ill.

IN a water purification plant where lime is employed as at Springfield, the pH value of the water is manipulated up and down in order to obtain certain results. These results have a bearing on the softening of the water and also on coagulation, sterilization, and ultimate stabilization. The practical values derived from these ups and downs of pH vary under different circumstances, but an examination of one more actual case may show some of the limitations of the process and help to point the way to better application of the phenomena involved.

At the Springfield plant the raw water is treated with lime in a small dosing well just ahead of the mixing chamber. It is then stirred for 40 minutes by mechanical agitators in two parallel mixing chambers from which it flows to clarifiers and settling basins having combined detention periods of 5 hours and 40 minutes at the rated capacity of the plant. A 30-minute carbonation period follows the settling, and the water then goes to the filters.

Method of Feeding Lime. — The method of feeding the lime is unique in that there is a marked variation each hour in the concentration of the milk of lime flowing to the dosing well. This is due to the fact that the quick lime is weighed into the slaker in hourly batches while a constant stream of water enters the slaker and displaces the milk of lime.

The magnitude of the variation is disclosed by a chart from the recording thermometer which has been placed in the pipe carrying the lime suspension (Fig. 1). The purpose of the thermometer is to give a continuous record of lime dosage for the benefit of the operator as well as the superintendent. I believe it is a valuable aid in maintaining the efficiency of the plant. As indicated by the chart, the lime suspension is, roughly, twice as concentrated immediately following the addition of a charge of lime to the slaker than before the addition. When this pulsating treatment was begun it was found to lower the total hardness of the treated water 10 p.p.m. more than could be done with the same amount of lime fed at a uniform rate.

When treating to normal carbonates only, there is considerable fluctuation in the pH and alkalinity of the mixing chamber effluent which is smoothed out by the time the water has passed the clarifiers. When treating to 40 p.p.m. causticity there is but little fluctuation in the alkalinity and the pH varies only 0.1 from 10.7 to 10.8. This is because the magnesium acts as a buffer removing the extra hydroxyl ions furnished by the peaks of the lime dosage.

Recarbonation. — The recarbonation of the settled water is accomplished with stack gas from the boilers of the nearby pumping station and power plant. The carbonating equipment includes two scrubbers, one gravel filter, one blower, a distributing grid submerged in the carbonating chambers, a CO_2 recorder, and a gas meter. There is also a 2-in. discharge line leading to the filtered water conduit which can be used to reduce the pH of the filtered water. The cost of the equipment was $7,000, of which $4,500 was for the pipe contract.

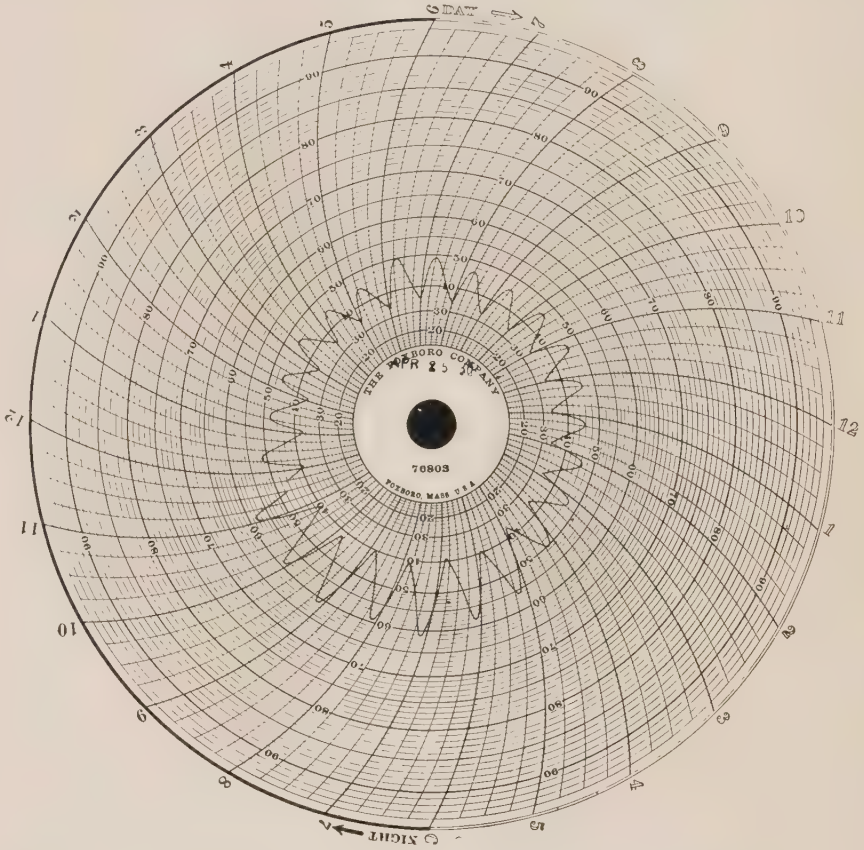


Fig. 1

The maintenance on the carbonating equipment was considerable at first, due principally to omission of the scrubber near the boilers. The compressor which is a rotary displacement blower, has not maintained its full capacity, but we do not find that this is a result of the character of the gas. During the past year the equipment has been operated with but little attention. The per cent of CO_2 in the gas is regulated by dilution valves admitting air as required to the suction of the compressor. The quantity applied is regulated by hourly tests of the carbonated water. The items of operating cost are power, $2.40 per day, and water $.77 per day, which together amount to 44 cents per million gallons.

The fuel used under the boilers from which this gas is taken is low grade bituminous screenings, containing 4 per cent to 5 per cent sulphur. Sulphur dioxide, however, is much more soluble than carbon dioxide, and the greater part is removed in the first scrubbing. There were predictions that chlorophenol tastes would be a problem if this gas were used. A few preliminary tests, however, showed that we had nothing to fear from phenols and the results have been entirely satisfactory in this respect. The soot and tarry compounds caused some trouble in handling the gas, and the single scrubber of the original installation was sup-

plemented by a second scrubber located close to the boilers. This materially helped matters, but the gas is still not as clean as could be desired, and various parts of the piping system require flushing-out every six months. Boiler operating conditions at present are far from ideal from the standpoint of clean smoke, but improvements are under way at the boiler plant which will permit better combustion and will probably remedy this situation, though it is not serious.

Effects of pH Values Compared.—A comparison of the effects of lower and higher pH values in the treated water can be made by an examination of the plant records for the years 1928 and 1929. In 1928 the settled water had a total alkalinity of 50 p.p.m., of which 1 p.p.m. was caustic and the balance normal carbonates. This water was filtered and the filtered water partially recarbonated in the filtered water conduit. The final effluent had a total alkalinity of 47, of which 28 p.p.m. were normal carbonates and the balance bicarbonate. In 1929 the settled water had a total alkalinity of 69 p.p.m., of which 35 p.p.m. were caustic and the balance normal carbonates. This water was carbonated before filtering to remove excess lime, and the final effluent averaged 35 p.p.m. total alkalinity, of which 28 p.p.m. were normal carbonates and the balance bicarbonate. Table No. I shows some results of these two treatments.

The record shows that the filtered water was 14 p.p.m. softer during 1929 than the previous year. The apparent lime cost per ton of hardness removed was $1.38 more in 1929 than the previous year; but due to the coagulating value of the extra magnesium hydroxide precipitate during 1929, a considerable cut was made in the amount of alum used, and this saving should be deducted from the softening cost. When this is done there is practically no difference in the per ton cost of hardness removed. During both years considerable hardness has been deposited on the filter sand. It has been found that when the sand grains accumulate a coating of scale equal to their own weight, filter efficiency begins to suffer appreciably, and it does not seem advisable to continue the process without replacing the sand. This means that one ton of sand is used in removing a ton of hardness from the water applied to the filters. The cost of filter sand delivered at the plant is $5.00 per ton. Allowing $1.00 per ton for handling in and out of the filters, brings the total cost of hardness removed in this way to $6.00 per ton, and lowers the average cost of all hardness removed to $10.56 per ton.

Table I

	1928	1929
Total hardness raw water, p.p.m.	248	230
Total hardness filtered water, p.p.m.	95	81
Total alkalinity raw water, p.p.m.	206	185
Total alkalinity filtered water, p.p.m.	47	35
Magnesium (as $CaCO_3$) raw water, p.p.m.	109	100
Magnesium (as $CaCO_3$) filtered water p.p.m.	70	50
Turbidity raw water	99	103
Lime used lb. per mil. gal.	1,386	1,461
Alum used lb. per mil. gal.	80	32

A comparison of the chemical costs of these two years is shown in Table II:

Table II

	1928	1929
Tons Hardness Removed by Lime Alone	1525	1451
Tons Hardness Removed on Filters	130	199
Total Tons Hardness Removed	1655	1650
Tons Lime Used	1794	1922
Tons Alum Used	104	42
Cost of Lime per ton, Hardness Removed	$ 11.00	$12.38
Cost of Lime corrected for Alum saved	.....	11.19
Cost of Sand per ton Hardness Removed	6.00	6.00
Cost of Lime and Sand per ton Hardness Removed	10.00	10.56

In spite of these figures it does not seem advisable to continue this sort of treatment. When settled water of pH 10.8 is recarbonated to 9.3, it is extremely unstable. It not only incrusts the sand but also the conduit and valves leading to the filters, so that in a few years these might become serious problems. Another problem which may be included among sequelae is magnesium silicate scale in hot water heaters.

Water of 30 to 30 p.p.m. alkalinity and pH 9.3 has shown no tendency to deposit calcium carbonate scale either in cold or hot water lines, but we have found in hot water systems a scale of which the following is a typical analysis.

Analysis of Silicate Scale

Loss on Drying	5.2
Loss on Ignition	17.0
Silica, SiO_2	35.1
Oxides, R_2O_3	3.64
Magnesium Oxide	37.5
Undetermined	.56

Water entering and leaving the heater from which this scale was collected showed the following changes through the heater.

Effect of Heater on Mineral Constituents

	Entering	Leaving
Alkalinity Total	32	28
Alkalinity to Phenolphthalein	9	28
Alkalinity to pH	9.3	9.1
Silica, SiO_2	13.2	7.8
Calcium Oxide, CaO	22.6	22.4
Magnesium Oxide, MgO	20.7	19.0

These analyses show that magnesium and silica are the important constituents in this case, and that calcium carbonate is out of the picture except, perhaps, as it affects the pH of the water.

The scale formed is soft, but it adheres sufficiently tight to effectively close hot water lines if not removed. Until we know more about this sort of scale, it seems advisable to use alum as a coagulant continuously and to keep the pH of the final effluent near 8.4.

The bacterial efficiency of the Springfield plant is based almost entirely on coagulation and chlorination. The line used plays an important part, but not as a sterilizer.

Acknowledgment.—The above is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

Garbage Collection and Disposal at Milwaukee, Wis.

The following note is abstracted from the 1929 report of the Common Council of Milwaukee, Wis.:

The city's present methods of handling its garbage dates from 1923 when a separate bureau of garbage collection and disposal was esbtablished and when the trailer system was inaugurated.

The city is divided into four sections, consisting of the east and north section, north central and west section, the south section, and the downtown commercial section. Three sections consist of eight tractor-truck units which are further subdivided into 32 trailer routes. A trailer route contains six districts contiguous to one another and of an area sufficiently large to constitute a day's work of 8 hours. These districts are numbered from one to six inclusive and designate the days of the week in which the teamster and his helper are to be working in their respective districts.

The fourth section consists of five "direct" routes and one commercial truck route. The "direct" routes are short, direct hauls adjacent to the incinerator which is located near the inner harbor entrance. One truck collects daily from the downtown hotels and restaurants in the commercial district, and also has assigned territory in newly annexed territory.

Only garbage originating in private homes is collected free of charge, while 20 ct. is charged for each can of commercial garbage of 20 gal. or less. Household garbage must be securely wrapped in strong paper, must contain only animal, fruit, or vegetable waste without liquids, and must be deposited in cans of an approved type.

The incinerator, built in 1910, contains four independent furnace units, each with a rated capacity of 75 tons of refuse per 24 hours, based on a mixture of 60 per cent garbage and 40 per cent ashes and rubbish. The present mix is 80 and 20. The ashes drawn from the grate are carried away in trailers and dumped at the lake front. This filling over a period of years helped in building enough new land for the present city airport. Plans for a new incinerator have been completed and funds are available.

The 46,782.3 tons of garbage collected during 1929 cost $5.26 per ton, or $0.44 per capita. In other words, the cost was 1 ct. a day for a family of five. A total of 62,135 tons of refuse, including garbage privately delivered and household ashes, was incinerated at a cost of $139,867.75. This incineration cost $2.25 per ton, as compared with $2.27 for 1928; the per capita cost was 25 ct. The net cost of operating the division—administration, collection and disposal—was $402,721.32, or 72 ct. per capita.

Water Treatment Works of Iola, Kan.

Some Details of New Filtration and Water Softening Plant Recently Installed

By M. P. HATCHER

Burns & McDonnell Engineering Co., Kansas City, Mo., and Los Angeles, Calif.

THE water supply of Iola, Kan., is obtained from the Neosho River. The present treatment at Iola includes only plain sedimentation and sterilization. The circulating water pumps on the power plant condensers discharge through the condensers to two settling basins of 2.5 and 3.5-million gallons capacity. These basins are operated on a fill and draw plan. Settled water is delivered by motor-driven centrifugal pumps in the power plant from these basins to the distribution system. No distribution system storage is at present available. Chlorine is applied to the suction of the high service pumps.

The extent of pollution in the Neosho River and the quantity of suspended matter transported point readily to filtration as a part of any adequate plan of treatment. A consideration of the mineral constituents made it apparent that lime softening could be added to advantage.

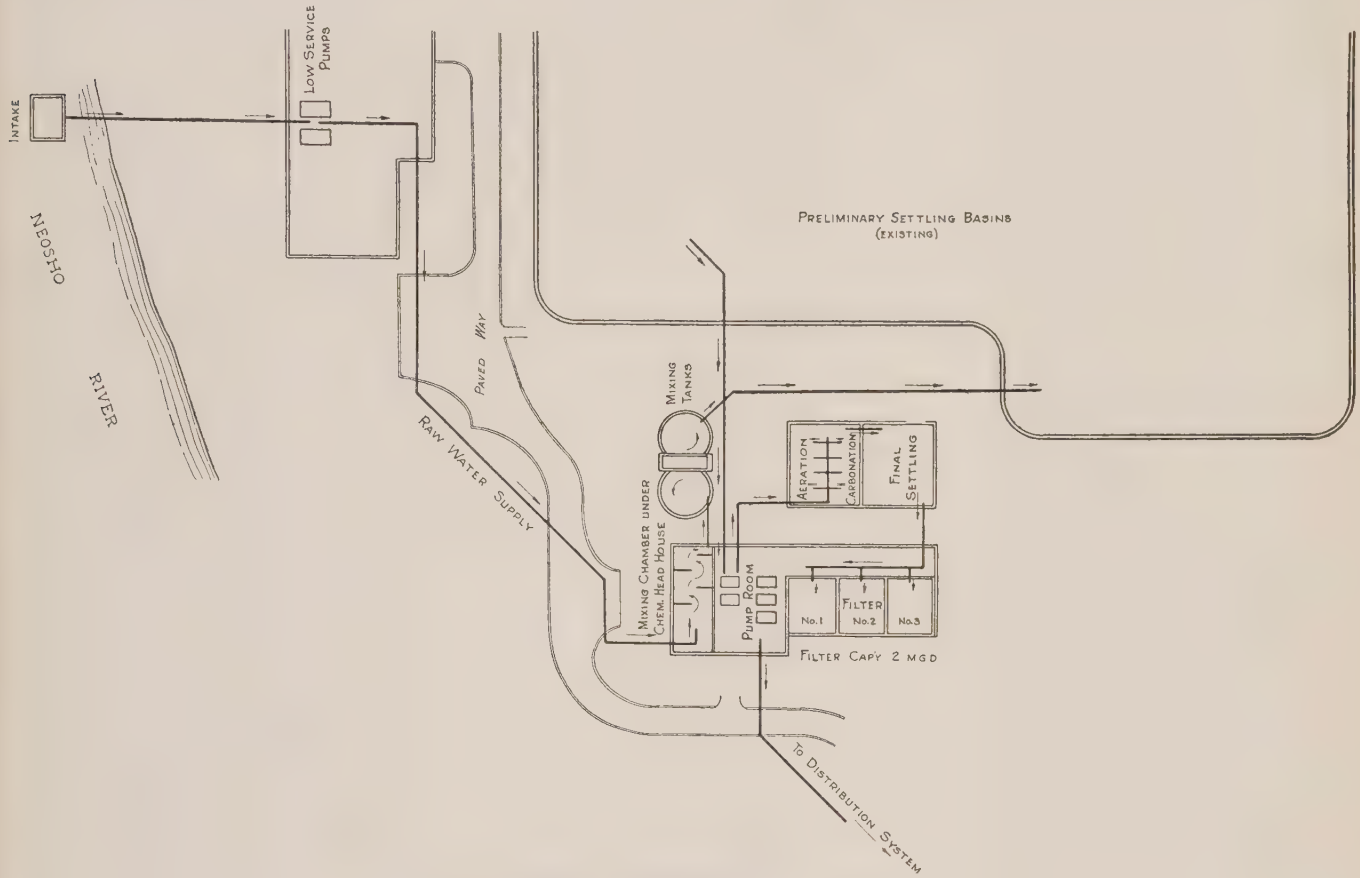
Character of Supply.—The lack of continuous records makes it difficult to picture accurately the character of dissolved solids in the water. Hardness varies from about 100 to 500 parts per million, with an average of 225 to 250 parts. Most samples show this hardness to be due largely to calcium in the carbonate form, which generally represents from 65 per cent to 75 per cent of the total hardness. Magnesium is usually lower than 20 parts per million. During low flow periods the effect of oil field pollution is indicated by a chloride content as high as 500 to 700 parts per million. Most of the year, however, the chloride content is less than 400 parts.

It was necessary in the design of the filtration and softening plant to keep the cost at an absolute minimum, consistent with good practice, and to confine the structures to limited areas available near the existing basins. Two million gallons per day was adopted as the nominal capacity of the new plant, with provisions for extension of the various plant facilities. Space for high service pumping equipment was provided in the new plant in order to centralize operation and provide for increased capacity not possible in the present location.

New Treatment Plant.—The new treatment may be best described by reference to the various facilities in their proper sequence: Raw water will be delivered by the present low service pumps in the power plant through the plant turbine condensers to the mixing chamber below the chemical application room. Lime from dry feed machine and lime slaker is applied at the entrance to this chamber. The mixing chamber is the usual under-and-over baffled unit having a retention period of about nine minutes and a velocity of 0.8 ft. per second. High velocities are maintained in this unit to preclude the possibility of deposition of suspended matter.

After this preliminary mixing operation the lime treated water passes to the reaction tanks. Reaction is obtained by an adaptation of the spiral inward flow principle, using a low-head drainage-type centrifugal pump to maintain circulation in two circular tanks of the same size and shape. These reaction tanks have a nominal retention period of about 30 minutes.

The discharge from the reaction tanks passes through an 18 in. steel pipe through sluice gates to either or both of the existing basins. The total ca-



Water Softening and Filtration Plant of Iola, Kan.

pacity of these basins represent a retention period of about three days. While the average retention period will no doubt be reduced below this time, it is evident that excellent lime reaction and sludge removal should be obtained.

Water Softening. — Auxiliary low service pumps in the new pump room deliver the water from these settling basins to the aerator and carbonating basin. Aeration is obtained through the use of the Sacramento spray nozzle, the discharge falling into the carbonation chamber beneath. Carbon dioxide from a natural gas generating plant in the chemical head house will be distributed through a grid system on the floor of the carbonation chamber. A 30-minute retention period is provided in this unit.

The carbonation basin is followed by an alum reaction chamber wherein a hydrate floc is produced to provide a proper mat on the filters which follow. The alum is applied by dry feed machine in the head house to the suction of the auxiliary low service pumps. The reaction proceeds through the carbonating chamber—the resulting floc being conveyed by controlled velocities through the alum reaction chamber to the filters. Some of the floc (depending on the character and amount of suspended matter in the water) will settle in this basin, thus reducing the filter load, but the major portion will be carried to the filter bed to form the hydrate mat so necessary to proper filtration.

Filtration Plant.—Filters are provided in three units each, capable of filtering about 667,000 gal. per day. Filtered water passes to the storage reservoirs below the filters, pump room and secondary basins. A total of 215,000 gal. of filtered water storage is provided.

The arrangement of filtered water reservoirs in three units offers greater flexibility in operation and better circulation than is generally obtainable in this unit of a treatment plant.

The filtered water reservoir is arranged in three separate units, all interconnected. In normal operation the filter effluent will dicharge to the space below the filters, passing through the reservoir below the secondary basins, thence to the reservoir below the pump room. Chlorine is applied at the entrance to the last reservoir.

While the filtered water storage capacity is sufficient for normal requirements, it may not be sufficient to meet the requirements of a 6 to 10-hour fire. For such extreme emergencies a provision is made whereby the upper 5 or 6 ft. in the primary basins will flow by gravity past the point of chlorination to the filtered water reservoir below the pump room floor, being delivered then by the high service pumps to the distribution system.

Quick lime will be used for softening, as mentioned before. The lime will be purchased in bulk, delivered to the railroad siding on the plant site, and hauled by truck to the unloading dock of the chemical head house. The lime will be unloaded to a hopper whence it will be carried by a bucket elevator to the steel storage bin above, with a capacity of about 75,000 lb. or 30 to 45 days' supply. The lime will feed by gravity to the lime dry feed machine, thence to lime slaker, then to the point of application in the mixing chamber.

Alum will be delivered in 200 pound sacks, which will be trucked to the loading dock and carried by the bucket elevator to a steel alum storage bin above. The bin has a capacity of about 20,000 lb. or 40 to 60 days' supply. The alum will discharge by gravity to the dry feed machine, thence to the suction lines on the auxiliary low service pumps.

Laboratory and office space is provided on the floor over the pump room. Sufficient laboratory equipment will be purchased and installed to provide control of softening operations.

A steel storage tank of 150,000 gallon capacity has been purchased to equalize pumpage rate and head. The tank is furnished and erected by the Pittsburgh-Des Moines Steel Company, Des Moines, Iowa.

The general contract for buildings and structures has been let to Fry Brothers, Iola, Kan. Pumps will be furnished by the De Laval Steam Turbine Company, and electric equipment by General Electric Co. Filter equipment will be furnished by E. W. Bacharach & Co., and chemical feeding equipment by the Omega Machine Company, both of Kansas City, Mo.

Plans and specifications were prepared by Burns & McDonnell Engineering Company, Kansas City, Mo.

Acknowledgement.—The foregoing is a paper presented before the Kansas Water Works Association.

100 Year Rainfall Records in New England

The June issue of the Journal of the New England Water Works Association contains 192 pages of rainfall tables, the records covering the New England states, eastern New York and south eastern Canada. The paper was prepared by X. H. Goodenough, Chief Engineer, Massachusetts Department of Public Health. In the introduction he gives the following information regarding some long time rainfall records:

Records of rainfall for more than 100 years are now available at four places in New England, all of which are in eastern Massachusetts, viz., at New Bedford, beginning in 1814; at Boston, beginning in 1818; at Waltham, beginning in 1825; and at Lowell, beginning in 1826. The rainfall observations at these places have been continuous at some point in the municipality indicated since they were first established, and though there have been changes in the location of the rain gauges these changes do not appear to be such as to be likely to cause a material variation in the amount and distribution of the precipitation in the localities indicated.

An inspection of the tables for the four stations mentioned above indicates that the rainfall for many years in the beginning up to about the year 1850 and again in the years following 1903 was considerably lower on the average than in the middle years of the 100-year period. This variation is shown in Table I in which the average rainfall is presented at each of the four stations for periods of approximately 25 years, beginning in 1826.

From this table it appears that in the period from 1850 to 1876 and again in the period from 1877 to 1903 the precipitation was considerably higher at all of the stations with the exception of New Bedford than in the earlier period from 1826 to 1849, or in the period from 1904 to the present time.

While aside from the records at the places included in the above table there are no records which cover a period of 100 years, there are a number which have been continuous for a period of more than 75 years in the same localities, viz., at Providence, R. I.; Amherst, Cambridge and Springfield, Mass.; Gardiner, Me.; and Burlington, Vt. There is also a long record at Lynnfield, Mass., beginning in 1842, by combining which with observations at Reading and Winchester, which are in the same general neighborhood—the Reading station being about 3½ miles northwest and Winchester about 7 miles southwest of Lynnfield—it is practicable to compile a continuous record for that general neighborhood for a period of 88 years.

The comparative average rainfall at these stations for the last three of the periods shown in Table 1 are given in Table II.

Table II shows results for the period since 1850 quite similar to those for the same periods in Table I.

Table I—Average Annual Rainfall by Periods (Inches)

Period		New Bedford, Mass.	Boston, Mass.	Waltham, Mass.	Lowell, Mass.
1826-1849—24	years....	47.21	42.00	41.13	39.45
1850-1876—27	years....	46.73	53.18	43.00	45.73
1877-1903—27	years....	47.79	45.52	44.40	45.95
1904-1929—26	years....	44.23	40.32	40.24	41.43
1826-1929—104	years..	46.49	45.40	42.24	43.26

Table II—Average Annual Rainfall by Periods (Inches)

Period		Providence, R. I.	Amherst, Mass.	Cambridge, Mass.	Springfield, Mass.	Gardiner, Me.	Burlington, Vt.	Lynnfield, Mass.
1850-1876—27	years.....	46.55	45.82	47.20	46.04	45.33	33.20	47.29
1877-1903—27	years.....	48.56	45.37	43.31	46.52	44.30	32.41	43.80
1904-1929—26	years.....	44.63	41.75	38.03	38.76	40.90	31.04	39.88
1850-1929—80	years.....	44.60	44.35	42.91	43.84	43.54	32.23	43.71

Maintaining Chemical Balance to Resist Corrosion

How Water May Be Treated So That It Will Deposit an Impervious Film to Prevent Corrosion

By CHARLES P. HOOVER

Chemist in Charge, Water Softening and Purification Works, Columbus, Ohio

A FEW commonly used remedies for preventing corrosion are as follows:

(1) Boiler feed water is usually preheated in open feed heaters in order to drive the oxygen out of the water. The elimination of the oxygen minimizes corrosion.

(2) It has already been stated that the lower the pH, the higher will be the amount of iron that will be dissolved in it. The reverse of this is also true. The higher the pH, the smaller will be the amount of iron water that will be dissolved. It is therefore good practice to treat water that is to be used for boiler feed purposes with from 30 to 50 parts per million of alkalies in excess of that required to soften it.

(3) Corrosive water has been made non-corrosive by passing it through a bed of scrap iron or iron filings. In other words, instead of letting the water damage valuable pipes, heating coils or boilers, it spends its energy or aggressiveness for dissolving iron on scrap material.

(4) It is common practice to coat the interior of pipes with zinc, cement, tar or some other manufactured product.

(5) Speller [1] states that an application of 20 parts per million of alkalinity by the addition of sodium silicate (15.6 lb. of 40° Baume sodium silicate containing 6 per cent Na_2O per 1,000 cu. ft. of water) is sufficient to almost completely stop the action of water on iron.

(6) Corrosion can be prevented by adjusting the chemical balance of the water. Water may be so treated that it will deposit an impervious film on the inside of a pipe or on iron surfaces with which it comes in contact. This film will prevent the water from coming in direct contact with the iron and will thus prevent corrosion.

How to Build Up a Film with Calcium Carbonate.—It is this phase of the problem that we now wish to emphasize. The film can be built up with calcium carbonate. To build up a deposit with calcium carbonate, the water must be saturated or at least almost saturated with calcium carbonate. Water that is super-saturated with calcium carbonate will quickly deposit a coating or film on the inside of the pipe. Water that is almost saturated, and this applies to numerous natural supplies, will also deposit a protective coating because in the process of corrosion, CO_2 is taken from the water.[1] The solubilty of calcium carbonate in natural water depends on the CO_2 content, therefore, if some of the CO_2 is absorbed, the nearly saturated water becomes saturated or perhaps super-saturated. As soon as this point is reached, deposition of calcium carbonate starts and the corroding iron becomes coated with a protective film of calcium carbonate. Water that is under-saturated with calcium carbonate, will dissolve any calcium carbonate film already formed. How is it to be known whether or not water is saturated, super-saturated or under-saturated with calcium carbonate?

Determining Saturation Conditions of Water.—The test to determine this is a very simple one and was outlined to the writer by Mr. John R. Baylis.[2] To carry out the test in a practical way where extreme accuracy is not required, proceed as follows: Divide the sample of water to be tested into two parts. Determine the alkalinity to methyl orange on sample No. 1 and record the results obtained. To sample No. 2 (say to 150 c.c.) add a considerable excess of calcium carbonate, stir a few minutes, settle, filter and determine the methyl-orange alkalinity. If the alkalinity of sample No. 2 is higher than the alkalinity of sample No. 1, the result shows that the water is under-saturated because calcium carbonate has been dissolved. In other words, the results show that the water tested is capable of dissolving and holding in solution an additional amount of calcium carbonate. Such water would dissolve a protective calcium carbonate coating. If the alkalinity is exactly the same on both samples, this would indicate that the water is neutral to calcium carbonate, that is it will neither dissolve nor deposit calcium carbonate.

If on the other hand, the alkalinity of sample No. 2 is lower than the alkalinity of sample No. 1, then the sample is super-saturated with calcium carbonate and will drop a deposit when the water comes in contact with iron surfaces. I am not prepared to state the theory as to why the addition of excess calcium carbonate throws calcium carbonate out of solution. It may be reaction induced by contact. The finely divided calcium carbonate furnishes numerous or multiple contact points.[3] What is the saturation point, or, in other words, how much calcium carbonate will water hold in solution? A curve by Baylis [4] shows that the approximate solubility equilibrium of calcium carbonate varies from about 15 parts per million to over 350 parts per million, between the pH value 6.8 and 9.3. At a pH value of 9.0, for instance, water is saturated with calcium carbonate when it contains only about 20 parts per million, whereas 350 parts per million is held in solution, if the pH is, for instance, say 6.8.

Corrective Treatment.—In using the chemical balance process to build up a protective coating, care must be taken not to continue the building up process too long because if it is continued too long, pipes will become clogged. This is exactly what has happened in many municipalities having lime soda-ash water softening plant. The water produced being super-saturated, resulted in too much deposit in the pipe lines, meters and heating coils and a means for preventing this had to be found. A practical corrective treatment process has been perfected and the trouble has not been entirely overcome by the process of recarbonation, that is, by adding carbon-dioxide gas to the water. Protective films built up by calcium carbonate will not last very long if the water brought in contact with them is under-saturated, because the under-saturated water will dissolve them. If water is super-saturated and forms too much deposit, this condition can be corrected as already explained by the additon of carbon-dioxide. The next question we have to consider then is, how can the water be corrected if it is under-saturated with calcium carbonate? The first thing to do is to determine the calcium carbonate content of the water. If it is found that the calcium carbonate content of the water is, say, something less than 20 parts per million, then it is necessary, if corrosion is to be prevented, to build up the calcium carbonate content. This can be accomplished by adding lime to the water, or if the water already contains some calcium sulphate, soda-ash can be added and the results will be satisfactory, because soda-ash reacts with calcium sulphate to form calcium carbonate, or it may be convenient to build up the calcium carbonate content by adding some hard water.

After the calcium carbonate content

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(1) Recent Developments in Water Treatment by Baylis, 33rd Report American Society for Municipal Improvements.

(2) Chief Filtration Chemist, Bureau of Engineering, Chicago, Ill., private communication.

(3) The term "multiple contact points" has been suggested by A. E. Kimberley.

(4) Industrial and Engineering Chemistry, July, 1927.

is known, the next thing to do is to build up the pH value if necessary. The most satisfactory way in which to build up the pH seems to be by the use of soda-ash. It has been our experience in working with soft water, that if enough soda-ash is added to give the water a distinct deep color to phenolphthalein, satisfactory results will usually be obtained. After the calcium carbonate and pH adjustments have been made, it is easy to determine whether or not the water is saturated, super-saturated or under-saturated by making the calcium carbonate test that has already been described.

This method was first used successfully to prevent corrosion in Baltimore.(4) I personally have had occasion to use it during the past year on an elaborate iron pipe cooling system. In this case, the cooling water is softened to about 25 parts per million, then enough soda-ash is added to give the water a distinct phenolphthalein alkalinity. Each day the water is tested for chemical balance. If the water is found to be under-saturated, additional soda-ash is added. On the other hand, if the water is super-saturated, the carbon-dioxide treatment is increased.

The tests are so easily and so quickly made that any operator should be able to determine without difficulty whether or not the water produced at his plant is in chemical balance or equilibrium and to predict the results to be expected in the distribution system.

Acknowledgment.—The above is an abstract of a paper presented at the 8th annual Three Day School at the University of Kansas and 5th annual meeting of the Kansas Water Works Association.

The National Hydraulic Research Laboratory

The American Engineering Council has announced the appointment of six representatives of the civilian engineering profession to serve on an Advisory Committee which under Dr. George K. Burgess, Director of the U. S. Bureau of Standards, will plan the design and equipment of the national hydraulic research laboratory recently authorized by Congress.

Two of the members chosen, John R. Freeman of Providence, R. I., internationally known authority on hydraulics, and William B. Gregory, professor of experimental engineering in Tulane University, will, it is also announced, spend several months studying the principal hydraulic laboratories of Europe, particularly those of Berlin, Munich, and Zurich.

Mr. Freeman, who is president of the Manufacturers Mutual Fire Insurance Co., and a past president of both the American Society of Civil Engineers and the American Society of Mechanical Engineers, has prepared tentative plans for the new Laboratory, which will be established in the Bureau of Standards, Washington, at an initial cost of $350,000. The building will be completed in about a year, and the laboratory will begin to function in two years.

It will be especially arranged for investigating the physical laws which define the motion of water, and for studying, by means of models and other special equipment, engineering problems arising in connection with measurement, control and disposition of large quantities of water, and the utilization of water for irrigation and power purposes.

Other engineering members of the Advisory Committee, which will at once begin consideration of the plans submitted by Mr. Freeman, are: Sherman M. Woodward, professor of mechanics and hydraulics in the University of Iowa; Lewis F. Moody, consulting engineer of Cramp-Morris Industrials, Inc., Philadelphia; Ely C. Hutchinson, editor of "Power," New York; Blake R. Van Leer, assistant secretary of the American Engineering Council, Washington.

On the Committee also are the following representatives of Government departments: J. P. Dean, office of Chief of Engineers, War Department; S. H. McCrory, Chief of the Division of Agricultural Engineering, U. S. Bureau of Public Roads, Department of Agriculture; N. C. Grover, Chief Hydraulic Engineer for U. S. Geological Survey, Department of the Interior; E. W. Lane of the Reclamation Bureau, Department of the Interior, Denver, Colo.

The laboratory will determine fundamental data useful in hydraulic research and engineering, including laboratory research relating to the behavior and control of river and harbor waters, the study of hydraulic structures and water flow, and the development and testing of hydraulic instruments and accessories.

Scores of problems already await study in the new Laboratory. Many require special equipment the cost of which is prohibitive for the individual manufacturer. These problems include phenomena involved in flood control and in the design of structures for Boulder Dam. Hydroelectric power companies, it is said, will be benefited by additional data relating to the design of trash racks, ground sluices, deflecting walls, intakes, spillways, etc.

There is now being conducted at the Bureau of Standards an investigation of flow in plumbing stacks and drains which is financed in part by the plumbing industry. Many millions of dollars are spent yearly in the United States for plumbing, but as yet only a small amount of scientific work has been done in establishing the design of plumbing systems, particularly for large buildings, on a solid basis. The present investigation is seriously hampered by lack of equipment which a national hydraulic laboratory would supply.

In number and extent of the problems to be considered the Laboratory, according to engineers, will surpass any in Europe. Through Mr. Freeman, data on researches in hydraulics both in America and abroad have been compiled. Among the foreign cities which have laboratories are Darmstadt, Dresden, Stockholm, Graz, Charlottenberg, Berlin, Wilhelmshafen, Braunschweig, Karlsruhe, Vienna, Danzig, Brunn, Munich, and Leningrad.

City Held Liable for Sewage Flooding Basement

The city of Tacoma, Wash., was held liable for damage resulting from sewage being forced back on to private property because of an obstructed or inadequate sewer in a decision handed down April 9, 1930, by the Washington Supreme Court (Boyer, et ux. v. City of Tacoma, 286 P. 659). "Public Health Reports," June 6, 1930, comments on the decision as follows:

The plaintiffs' property was connected with a sewer, which connection was required by the defendant city under the terms of a city ordinance. The connection conformed to the ordinance and was approved by the city's inspectors. Either because of some obstruction in, or the overtaxing of, the sewer, the sewage was forced back through the drainpipes of the plaintiffs into their basement. The sewer had been installed approximately 20 years before the flooding of the plaintiffs' premises and, when installed, it was undoubtedly of ample size. However, by reason of the growth of the territory served, it had become inadequate. No extraordinary storm conditions existed at the times when the premises were flooded.

An action was brought against the city and plaintiffs lost in the trial court. On appeal the supreme court stated the question as follows:

> Is the city liable under circumstances such as these for sewage discharged on plaintiffs' property, they having been compelled by ordinance to connect with the sewer, the connection having been made in the manner approved by the city, and there being no negligence of any kind on their part?

The appellate court held that there was liability on the city's part, saying:

> "* * * The theory of all of the cases which we have examined which hold the city liable under circumstances such as we have outlined above seems to be that the property owner is required to connect with the sewer; that he is not permitted to dispose of his sewage in any other way than the one way provided by the city; that he has no power or authority to remove the cause, or to in any way remedy the defect from which his injury arises; that the city alone has the power and the means to remedy the defective sewer or to replace an inadequate sewer; that no person should be required to suffer an injury caused by an agency over which he has no control and over which the city has absolute control; and that if an injury is inflicted by such an agency, he should be properly compensated therefor. We think this is the better rule and is well supported by both reason and authority."

Customer Accounting in a Water Department

An Interesting Description of the System Employed by the Department of Water Supply of the City of Detroit, Mich.

By HAL F. SMITH

Head Water Consumers Clerk, Department of Water Supply, Detroit, Mich.

THE Customers Accounts Division is divided into three bureaus, the Assessment Bureau, Customers Accounts Bureau, and the Collection Bureau. The work of these bureaus is so closely related that it is difficult to draw a definite line between them. For that reason, only by a sincere spirit of cooperation can a high standard of efficiency be maintained. Fortunately that spirit exists. A clear picture of any customer accounting plan would be incomplete without a description of the meter reading methods, but as that has been described, I shall not repeat.

City 99.5 per Cent Metered.—We have approximately 251,000 active revenue accounts 99.5 per cent metered. Meters are read and billed quarterly under the cycle billing plan. The rate is a three step sliding scale structure with a minimum charge and a service charge based upon the size of the meter. Each account is billed for indicated consumption and for service charge, these charges being combined and billed as one item.

Consumers meters are owned and maintained by the department. No charge to the customer for service to the meter is made, except where it is wilfully damaged by him or through his neglect, such as failing to provide against freezing or in allowing hot water to back into it. These exceptions are, however, numerous and are mentioned at this time because it creates one of our problems.

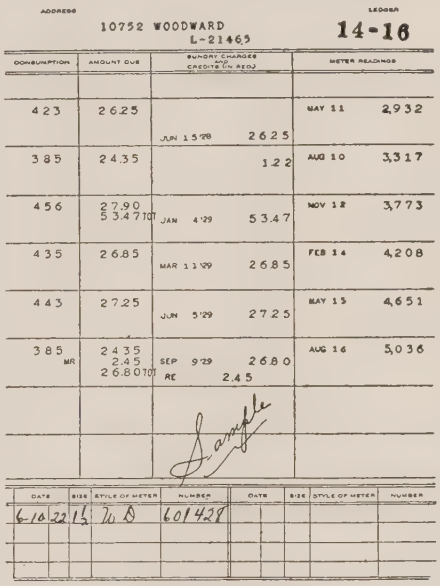
Combination Bill and Ledger Plan.—We are operating under the so-called combination bill and ledger plan of customer accounting, using individual ledger cards. The three major forms are the ledger card (Fig. 1), the bill (Fig. 2) and the proof sheet (Fig. 3), sometimes called the abstract sheet.

Both sides of the ledger card are identically ruled, making possible a four-year continuous record. In the space at the top are shown lot number, house number, street, mailing list number, and ledger number. The headings at the top of the vertical columns indicate their use. Each space set off by horizontal lines is for one billing period, which is identical with our balancing period. It is absolutely essential for balancing purposes that each entry made to the card be made in the proper space, as most entries are not dated. The space at the bottom of the card is ruled for the meter record.

The bill form is self explanatory. You will note that current rates are shown in the net amount only, and that the bill carries the notice that a 5 per cent penalty charge will be added after the indicated due date.

The abstract sheet is ruled to receive carbon impressions of the bill. The purpose of this important form will be later described.

Cycle Billing.—For the benefit of those who did not hear the paper on meter reading, the city is divided into



ADDRESS 10752 WOODWARD L-21465 LEDGER 14-16

CONSUMPTION	AMOUNT DUE	SUNDRY CHARGES AND CREDITS (IN RED)	METER READINGS
423	26.25	JUN 15'28 26.25	MAY 11 2,932
385	24.35	1.22	AUG 10 3,317
456	27.90 53.47 TOT	JAN 4'29 53.47	NOV 12 3,773
435	26.85	MAR 11'29 26.85	FEB 14 4,208
443	27.25	JUN 5'29 27.25	MAY 15 4,651
385 MR	24.35 2.45 26.80 TOT	SEP 9'29 26.80 RE 2.45	AUG 16 5,036

Sample

DATE	SIZE	STYLE OF METER	NUMBER	DATE	SIZE	STYLE OF METER	NUMBER
6-10-22	1½	W D	601428				

Fig. 1.—The Ledger Card

three zones, each zone into twelve districts, and each district into routes. Each route contains a sufficient number of accounts to represent one day's work for a reader; they average 165 accounts. The reading unit is permanent, and is used as our balancing unit.

A moment's consideration of the above described division of the city will make clear the principle of cycle billing. Remember that each account is billed every three months. We have three zones. Therefore, one zone must be billed each month. Each zone contains twelve districts, and as the twelve districts must be completed in a month, each district must be completed in approximately two days. That is, each operation in each district must be completed in two days, whether it be reading, billing, collecting, balancing, or any of the other operations, if schedule is to be maintained. It is thus seen that every operation is a continuous one, thereby eliminating peak loads and making an even flow of work, not only possible, but absolutely essential.

Meter reading sheets are arranged in the order found to be most suitable for reading. They are locked into a binder, making this order permanent. Ledger cards and addressograph plates are filed in identical order of the reading book, thus eliminating any sorting at the time of billing. Ledger cards are filed in a room used exclusively for that purpose and may be withdrawn on requisition only. This practice has almost entirely eliminated the lost or misfiled card.

Mechanical Devices.—Every operation which, in our opinion, can be done practically by machinery is done by machinery. With the present wide range of highly efficient bookkeeping and calculating devices, there is very little need for long methods or mental calculations. With the exception of a battery of comptometers, we are entirely equipped with Burrough's machines, using their public utility machines for billing, their cash posting machines, and their various type adding machines.

Mailing List Plan.—While this general discussion is on, it might be well to describe our mailing list plan. All bills are delivered by our own force, directly to the premises served, except when requested otherwise by the owner. Approximately 30,000 owners have requested otherwise, that is, they have requested their bills for their properties be mailed either to themselves, to a certain real estate management company, or to a trust company. Out of our total of 251,100 accounts, the bills for approximately 75,000 are mailed in accordance with the owner's instructions. This volume demands a carefully thought out system in order to give the customer the kind of service he expects and deserves and yet hold to reasonable costs.

Our plan is this: Every owner, desiring this service, lists his property, giving the name and address to which the bills are to be mailed. A list number is then assigned and this number is applied to each ledger card affected, and to the corresponding addressograph plates. Then an addressograph plate is made carrying the mailing address and the list number and filed numerically by list number. From this plate two index cards are printed, one filed alphabetically by name and the other numerically by list number. Since the list number has been applied to the bill addressograph plate, each bill will carry its proper list number. The last operation, before turning the completed bills over to the Assessment Bureau

for delivery, is to pull all bills bearing a list number. These are then sorted into numerical order by list numbers, thus throwing all of a like number together. This sorting, completed, they are sent to the Addressograph Department, where the corresponding mailing plates are pulled, and with them envelopes are addressed. The envelopes will also bear the list number and will be in the same order as the bills. It is then but an operation of putting bills bearing a certain list number into the envelopes bearing the same number. Special sorting equipment and an electric envelope sealer are used.

Opening Consumers Accounts.—Consumers accounts are opened upon receipt of the meter installation report, at which time an addressograph plate is made and applied to a ledger card, upon which is entered the meter installation record. The card is then regularly filed in readiness for the initial billing.

Sundry debits are posted by machine to the ledger card prior to the billing date. Our sundry debits consist of meter repair charges, penalty charges, refunds, and debit transfers. All items posted to the card are immediately reported to the control keeper for entry to the control ledger.

Meter repair charge slips are received daily from the meter shop. They are indexed as to ledger number and sorted to districts. Total charges for each district are ascertained and entered to a memorandum ledger. These slips are then filed by districts. The day before District 11, for instance, is to be billed, all charge slips for that district are turned over to the debit poster, together with the corresponding ledger cards. Each item as posted to the card is transferred to a proof sheet by use of a duplicate carbon roll. At the end of each control unit, a transfer total is taken, and at the end of a district, a grand total. The grand total must agree with the above mentioned memorandum ledger. The proof sheet, showing totals charged to each control unit, is turned over to the control keeper.

Billing Work. — Burroughs public utility machines are used in our billing work. As most of you know, this machine types the bill, ledger card, and abstract sheet at one operation; the card and bill receiving original impressions, the abstract sheet being a carbon copy of the bill. The machine is so constructed that there is a mechanical assurance that certain operations are properly performed. It is equipped with a lock that prevents a change in the set-up during an automatic repeat print operation, thus assuring that the charges shown on the bill are identical with those on the cashier's stub. Another check that the machine makes is the verification of the meter reader's subtraction. The operator follows the reader's figures. If the billed consumption does not represent the difference between present and previous readings, the machine will automatically indicate the error on the ledger card.

Billing assignments are made by reading books, which is equivalent to our control unit. The operator receives the reading book, addressed bill forms, and corresponding ledger cards, all of which are in the same order. She first puts in the present and previous dates and readings, then consumption, followed by the rate charge, which she calculates either mentally or by reference to a rate chart. The next step is to put in any unpaid balance as arrears, followed by the posting of sundry debits, if any, and then to show the total charge, which is, of course, a machine operation. Our standard production rate is set at 800 bills per day per operator. Actual production is running very close to this figure.

Bills are proven for accuracy in the internal audit and control division of the Bureau by means of balancing the proof sheet. A detailed description of this operation would be too lengthy and too hard to follow, without having a sheet before you, but it may be said, in a general way, that the proof rests in balancing the amount obtained by applying the rate to the total rate revenue of the sheet. This necessitates, of course, grouping water sold at the various steps, grouping the various service charges, and making corrections for certain rate peculiarities. Any one interested may refer to the display board where a balanced proof sheet clearly illustrates this operation. Any bills found to be in error are sent back to the billing division for correction. The balanced proof sheet not only certifies to the accuracy of the billing, but also supplies our trial balance, revenue distribution, and serves as the basis of all our statistical data.

Posting Cash.—It is the practice in some highly organized and very efficient utilities to hold up the posting of cash to customers accounts until after due date, thereby simplifying this work, and, of course, reducing costs. We tried this and distinctly did not like it. Water accounts in Detroit are not accounts with certain individuals, but with legally described pieces of property. Either the tenant, owner, or agent may pay the bill. Some confusion naturally results, causing considerable inquiries as to whether a certain bill is paid. These inquiries are usually received before due date. We want to be able to reply that the bill is paid or unpaid, rather than to report that the bill is unpaid, unless paid within the last ten days, in which case it would not show on the ledger.

A practice has been adopted, therefore, and rigidly maintained, of posting all cash received, on the following day. Bills are paid in person at the main office, by mail to the main office, and to banks and their branches throughout the city. In order to post cash the day following its receipt, it is necessary to sort stubs and pull ledger cards immediately following the close of the day's business, so as to have them ready for posting the following morning. A night force consisting of one senior clerk and four juniors do this work. They also run a tape of the stubs, taking a transfer total at the end of each control unit, and a grand total which should agree with the cashier's reported total. Ledger cards are pulled for posting, only from the inactive districts; the active districts

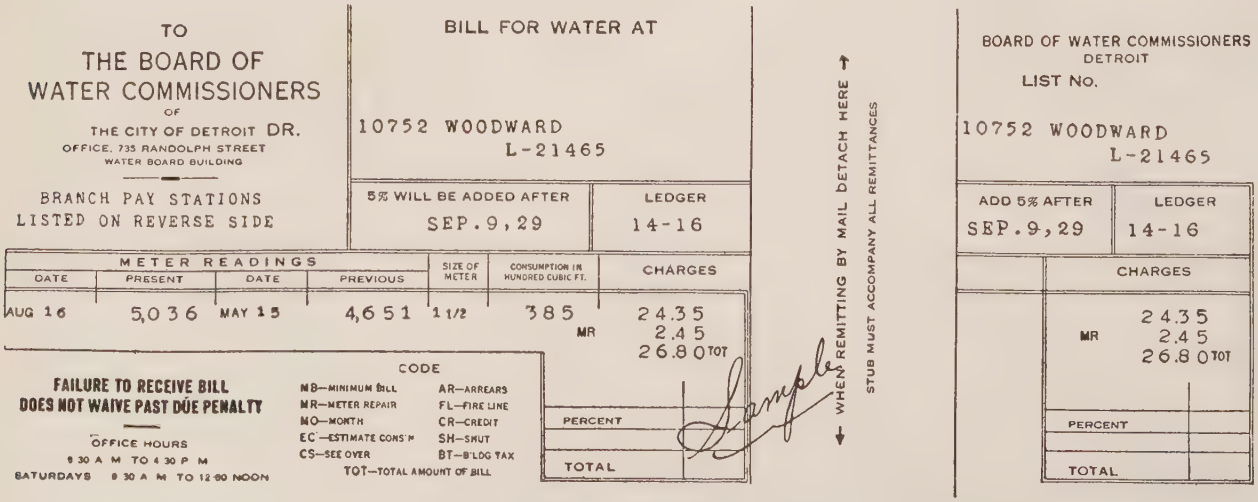


Fig. 2.—The Bill

are posted directly from the trays. The amount of each stub is posted in red ink to the corresponding card by means of a posting machine, which also makes a carbon impression on the proof tape. A transfer total is taken at the end of each control unit and a grand total at the end of each district. The transfer totals of the proof tape are then checked with the transfer totals of the tape run by the night clerk. Should there be any discrepancy it is immediately located and corrected so that at the end of a day's posting the total of the district totals will agree with the cashier's report. No difficulty is experienced in this operation. The tape run by the night clerk, which has been checked with the machine posting tape, is turned over to the control keeper for entry.

We should like to post penalty to all unpaid accounts immediately after due date, but this is impossible on account of bank payments. Most banks, and their branches, are very prompt in making returns, but due to a few, we do not feel safe in posting penalty until twenty days after due date. At this time a clerk, using a posting machine identical to the cash posting machine, except that it is equipped with a black record ribbon, posts the penalty charge to all accounts showing an unpaid balance, and to all accounts paid after due date. A transfer total is taken at the end of each control unit. A proof tape is used on this operation in exactly the same manner as in cash posting, and when the district is completed, the tape is turned over to the control keeper for entry. This operation is a continuous one, posting penalty to one district after the other, in accordance with schedule.

Collecting System.—At this point, collection work breaks into the picture, as the clerk posting penalty, also establishes the shut off list simply by setting aside all cards to which she has posted penalty that carry an item of arrears, indicating that not only is the current bill unpaid, but also all or part of the previous bill.

Our collection system is somewhat unique in that no delinquent bills are sent out. We are operating on the theory that money spent to collect a bill that we have every reason to believe will be paid without collection expense, is just so much money wasted, and further, that a good customer is unnecessarily annoyed. The plan is this: If a customer fails to pay a current bill, there is nothing done about it, provided that the account is paid in full to the current quarter. However, should this account still be unpaid at the time of the next regular billing, the unpaid balance is posted to the bill and the following form attached. If this account is not paid in full by due date, it is pulled by the penalty poster as above explained; a delinquent bill, giving all necessary data is made out and turned over to the Collection Bureau with orders to collect or shut.

All entries to the ledger card made at any time other than the scheduled time for that particular operation, are considered adjustments. All items posted to the control at the scheduled time are reported to the control by proof sheets. All entries made at any other time are reported to the control by adjustment slips. Under the classification of adjustments, then come: final bills, special bills, cancellations, refunds, transfers, and sundry debits. All adjustments are handled by the adjustment clerk, who makes the required entries to the card, writes the adjustment slip thoroughly describing the transaction, and presents it to the head of the bureau, or his assistant for an O. K.

Control Ledger.—You will probably agree that a customer accounting system that is not under complete control and in balance both internally and with the general ledger, cannot be considered satisfactory, no matter how well it appears to be operating otherwise. Our control ledger is entrusted to a senior clerk, acting as control keeper. A master control consisting of 40 controlling accounts, one for each of the thirty-six districts and four for other divisions peculiar to this department, is maintained. This ledger is arranged to show a complete revenue distribution, cash received, and balance outstanding, daily. It is a daily summary of all entries made to customers accounts. The control keeper receives his data from proof sheets and adjustment slips, as above described. A mathematical proof of control entry

Table 1.—Water Distribution Analysis, July 1, 1928, to July 1, 1929

Class Consumers	Rate	Number of Accounts		Consumption Cu. Ft.	Percentage of Pumpage
Domestic	Standard	221,904		3,025,339,091	24.87
Commercial	Standard	22,445		2,450,158,852	20.14
Manufacturing	Standard	1,796		2,307,725,857	18.97
U. S. Government	Standard	21		10,671,000	00.08
Suburban	Double	3,343		1,382,023,100	11.36
Semi-charitable institutions	Half	32		56,690,600	00.47
Water used for construction purposes	Special*	173	Est.	138,067,780	01.13
Charitable institutions	No charge	41		26,641,700	00.22
Municipal—metered	No charge	527		351,642,600	02.88
Municipal—unmetered	No charge		Est.	976,867,100	08.02
Main and service leakage based on pitometer survey			Est.	608,458,300	05.00
Water unaccounted for				834,881,600	06.86
Totals		250,282		12,169,167,580	100.00
Total pumpage in cubic feet				12,169,167,580	100%
Revenue producing pumpage				9,370,676,280	77%
Non-revenue producing pumpage				2,798,471,300	23%
Consumption revenue				$5,244,144.51	85.79%
Service charge				868,707.33	14.21%
Revenue from sale of water				$6,112,851.84	100.00%
Average revenue per 1,000 cu. ft. of total pumpage				$.652	
Average revenue per 1,000 cu. ft. of total pumpage				.502	

*This classification includes C. S., B. T., and Special Assessments. Number of Accounts for Special Assessment only are shown as C. S. & B. T. are not separate accounts but part of Standard Rate and are so distributed.

Pumpage in this report refers to the amount of water entering the distribution system as indicated by the Venturi Meter.

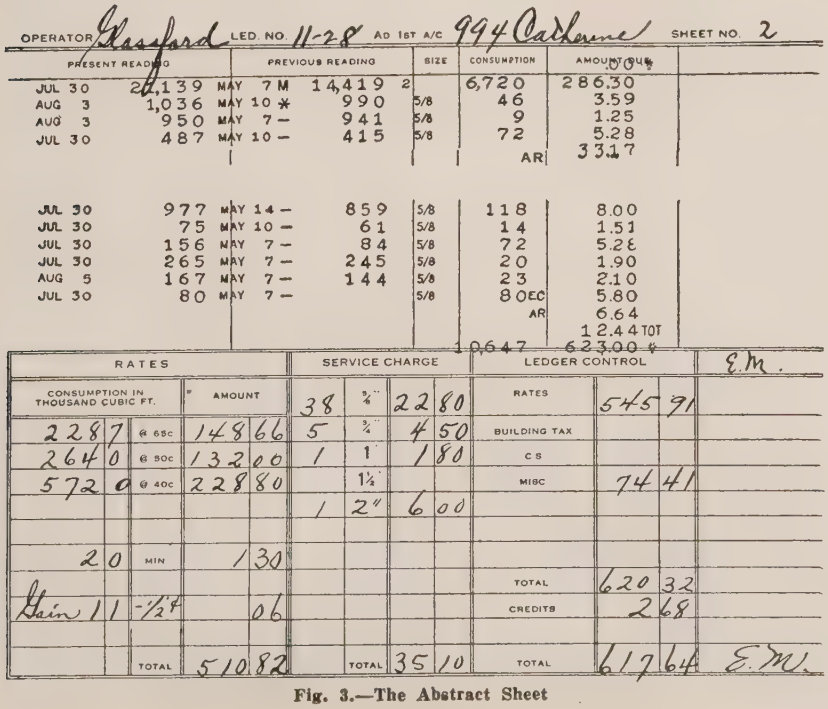


Fig. 3.—The Abstract Sheet

has been worked out and is applied daily. It is practically air tight assuring that entries are made in the correct amount, and in the proper place. Each of the district controlling accounts represents about 7,500 customers accounts. This is, of course, too many for balancing purposes, so a control was set up for each reading route consisting of approximately 165 accounts. Since we have at present 1,693 reading routes, it means that we have 1,693 of these sub-controlling accounts, known as route controls. To these accounts are entered only the balance at the last balancing date and the total daily debit and credit items. If the control is accurately kept, it will show balance outstanding in the corresponding route for any given date. If it were known that no error would ever be made to either control or ledger card, trial balances would be unnecessary, but we all know that in spite of all precautions taken to prevent it, errors will occur, hence a periodical trial balance is essential.

Running a trial balance of customers accounts is often considered a difficult and expensive operation; it used to be for us. It is now one of our simplest operations. You will recall that all unpaid balances are posted to the current bill, hence to the proof sheet. The sum of the individual balances for the route is then the outstanding at that time and should check with the control. If it does not, we have only 165 accounts to look through. The error is found in a few minutes, corrected and the controlling account is balanced.

The small control unit and the cycle plan of balancing have made this possible. The route control, acting as a sub-ledger to the master control is kept in balance at all times with the master control, which in turn is kept in balance with the general ledger by means of a monthly trial balance.

The abstract sheet contains a great deal of information readily available for statistical purposes. The compilation and tabulation of these data are daily routine operations.

Acknowledgment.—The above paper was presented before the Central States Section of the American Water Works Association and is reprinted here from the Journal of the Association.

New York City May Spend $500,000,000 on Its Water Supply

New York City is shown to be entering an era in which annual outlays for its future water supply during the next 12 years will be vastly heavier than in any period in its history, according to a survey on public construction prepared by Dr. Leo Wolman, statistician and economist, of the National Bureau of Economic Research. The survey has just been made public by the Committee on Recent Economic Changes of the President's Conference on Unemployment, which sponsored the undertaking.

The survey together with a report of the Committee on Recent Economic Changes have been published by the National Bureau of Economic Research under the title, "Planning and Control of Public Works."

Figures are presented in the survey showing that close to half a billion dollars may be required in the next 12 years to carry out New York City's water supply programs now underway and in contemplation.

Outstanding contracts amounting to more than $40,000,000, for the construction of a delivery tunnel to improve and safeguard the Catskill Mountain supply provide for average annual expenditures of $7,000,000, during the next five years or more than twice the average annual outlay for water supply in the 12-year period between 1907 and 1928 following the completion of the Ashokan dams and reservoir.

In addition to further developments of the Catskill Mountain supply system, New York City, the survey points out, has already taken the first steps in a new program for new sources of supply to be completed within the next 12 years, known as the Delaware River Supply Plan.

The cost of the Delaware River plan, according to figures of the New York City Board of Water Supply quoted in the survey, has been estimated at $273,000,000, the annual expenditures for the project having been scheduled as follows: First year, $3,000,000; second year, $10,000,000; third year, $20,000,000; fourth year, $40,000,000; fifth and sixth years, $45,000,000 each; seventh year, $40,000,000; eighth year, $25,000,000; ninth and tenth years, $15,000,000 each; eleventh year, $10,000,000, and the twelfth year, $5,000,000.

Figures presented in the survey furnished by the Chief Engineer of the New York City Board of Water Supply show that in the period beginning a quarter of a century ago up to the end of 1928, a total of about $184,000,000 was expended for the water supply system of the metropolis, which included the development of the Ashokan reservoir project and other developments of the Catskill Mountain water supply.

In no year during the early period of the Catskill Mountain project, when annual expenditures were heaviest was more than $19,500,000 expended, according to the figures presented in the survey. The contracts for the main Ashokan dams were awarded in the summer of 1907. Water supply contracts close to $100,000,000, were awarded in the years 1907 to 1914. Work on various developments cost the city $228,133 in 1907; $1,877,790 in 1908; $7,713,423 in 1909; jumping to $15,600,268 in 1910; further advancing to $19,104,290 in 1911 and $19,459,970 in 1912; dropping to $15,053,256 in 1913, to $11,026,495 in 1914.

After 1915, when annual costs for water supply construction were $4,309,893, the yearly costs were as follows: In 1916, $1,816,068; in 1917, $815,007; in 1918, $602,054; in 1919, $1,300,993; in 1920, $1,375,705; in 1921, $4,545,769; in 1922, $7,958,751; in 1923, $10,884,181; in 1924, $5,061,581; in 1925, $2,818,278; in 1926, $1,522,292; in 1927, $648,946, and in 1928, $205,545.

An estimated requirement of $483,000,000 in the fifteen year period 1928 to 1942, for New York's water needs, mentioned in "Regional Survey of New York and Its Environs," is referred to by Dr. Wolman as indicative of probable future expenditures.

Record-Breaking Turbine Generators

Two turbine generators that will set several records for capacity and size are being constructed at the Schenectady, N. Y. works of the General Electric Co. for installation in the Hudson Ave. station of the Brooklyn Edison Co., Brooklyn, N. Y. One will be installed in September, 1931, and the other in April, 1932.

Each turbine will be of tandem-compound construction, with double flow in the low-pressure cylinder, and will drive a single generator of 160,000 kilowatts capacity at 0.8 power factor, with a maximum output of 200,000 kilovolt-amperes. The unit is, therefore, the largest single-shaft machine operating at 1,800 revolutions per minute. Without auxiliaries or attachments the combined weight of each turbine and generator will be more than a thousand tons. The turbines are designed for steam conditions of 400 lb. gauge pressure, 730° total temperature, and 1 in. absolute back pressure. Provision is made for bleeding steam at two stages for heating the feed water to a temperature of 270° F. The compactness of the unit is shown by the fact that an output of almost 100 kilovolt-amperes is obtained from 1 sq. ft. of floor area.

The generator that will be driven by this turbine is an outstanding engineering achievement for it is the largest single generator in the world. Rated at 160,000 kilowatts, 16,500 volts and 7,000 amperes, it operates at 1,800 revolutions per minute. As it is an 0.8 power factor machine, the full load output of 200,000 kilovolt-amperes will be considerably greater than the output of the 160,000-kilowatt, 160,000-kilovolt-ampere generator now operating in the East River station of the New York Edison Co. Seventy-one of the new generators, operated continuously for one year, would generate close to 100 billion kiolwatt-hours, which quantity slightly exceeds the total electrical output of the United States for all purposes during 1929.

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Hoover Construction Program Lives Up to Expectations

The success of the Hoover plan of speeding up construction during dull times is now assured. On the last day of June the president announced that for the first six months of 1930 expenditures for public works had exceeded those of the corresponding period of 1929, by 12 per cent, and that a greater excess will occur during the next half year.

He pointed out that it takes time to initiate any marked expansion in so great an industry as the construction industry, for surveys and plans must first be made. He also pointed out that many of the federal appropriations did not become available until July 1.

With a note of pardonable pride President Hoover stated that this is the first time in history that a concerted and successful effort has been made to increase public works expenditures during a business depression. Hitherto cities, counties and states have followed the lead of many private corporations in curtailing construction during "hard times," for outcries were raised against increasing taxes at such times, and the outcries were heeded by the politicians. This time, however, the governors of all the states were invited to join in a nation-wide expansion of public works for the purpose not only of shortening the period of business depression but of providing employment at a time when there would not be jobs enough to go around. Not only were state and municipal heads enlisted in this great economic experiment, but also the heads of railways, public utility companies and large industries. The result has been an expansion of railway and public utility construction analogous to that in public works.

We venture the prediction that this experiment—now well beyond the stage of doubtfulness—will prove to be the most important feature of the Hoover administration. His combined engineering and business experience gave him confidence that construction expansion would serve to restore confidence and thus quickly to renew the usual business activity. Census statistics of unemployment now being made public, show that the percentage of unemployment is much smaller than had been supposed. This also will serve to restore general confidence, for there is no "whistling in the dark" as far as these census data are concerned. The same holds true as to the 12 per cent increase in public works construction.

It will be recalled that in January the forecast was made that public works in 1930 would involve fully a 10 per cent increase over 1929. At the end of the first half of the year, it is seen that that forecast was conservative. So when President Hoover now announces that the last half of the year will show an even greater percentage increase, there should be general rejoicing.

The Blighting Effect of a False Meteorological Theory

More than two centuries ago the scientific study of weather began, yet, aside from the gathering of data, that study has been singularly deficient in theories that are satisfactory. The reason for this barrenness is to be found, we think, in the hold that a false theory has had upon the entire meteorological profession. We refer to the convection current theory. It is beautifully simple, yet as erroneous as very simple theories so often have a way of being.

For every case where the convection theory seems to apply others can be cited where it fails. But where it fails to apply, meteorologists have invented special reasons, or rather excuses, for they have been obsessed with the belief that the convection theory must somehow be sound in spite of many evidences of its unsoundness.

Heat expands air; when expanded its decreased density causes it to float upward, just as a balloon ascends. Cool air flows in to take the place of the hot air that has risen, is in turn heated and ascends. Eventually a "chimney" of heated air may thus be created, and a convection current established. All this is beyond question, but does it explain the air currents that determine the weather? Does it even explain many of the important local air currents?

We are told that the summer monsoons of India are caused by the great "chimney" of hot air in Asia; and that the winter monsoons are caused by the "chimney" of hot air in the Indian Ocean. But Australia is a vast island that is intensely hot in summer, yet has no rain-bearing monsoons in summer such as those of India. Africa is another furnace with no inflowing summer monsoons to bring it such rains as India receives. The entire Pacific coast of North America is heated in summer, yet no summer monsoon rains occur there. The conventional excuse for the absence of strong, wet winds in summer in California is that California is so near to the permanent anticyclone in the Pacific that only dry air is fed into California. Unfortunately for that excuse, that anticyclone is strongest in winter when California gets her rains. Moreover, that anticyclone is too far from British Columbia to affect the climate there, yet British Columbia also is dry in the summer time. Here, then, is a coast several thousand miles long,

not to mention Mexico, that gets no summer monsoons, like those of India. If it be argued that mountain ranges along the Pacific act as barriers, how about the Himalayas in India? That is the highest barrier on earth.

Incidentally "peculiar topography" forms the commonest excuse for failure of the convection theory to apply to a given area. It is noteworthy that winds have no trouble in passing over the Rockies or the Himalayas, and that the summits of mountain ranges show great wind velocities in the windy seasons. A mountain range two miles high seems like a great obstacle until you compare it with a height of 20 miles or more. When Krakatoa exploded in 1884 dust at an elevation of 20 miles was carried three times around the earth at a velocity of 70 miles an hour by the general air current. To such air currents a range of mountains is little more than a ridge of pebbles in the bottom of a river.

Differences in barometric pressure are constantly cited by meteorologists to account for the flow of air from one area to another. Yet the greatest of such differences often exist between a cyclonic whirl and a sequent anticyclone, without the slightest evidence of a surface flow of air from the "high" to the "low." If it be replied that the distance between their centers is so great that the barometric gradient is not sufficient to overcome the friction, then such an answer itself destroys the entire theory of convective air currents of a general nature, for the barometric gradients are always slight. In fact they are so insignificant that a hydraulic engineer should be reluctant to believe that they explain the rapid air currents that often exist.

Perhaps the most fantastic of the applications of the convection theory is to be seen in its use to explain cyclonic storms. "Chimneys" of hot air are supposed to be localized sufficiently to start a strong ascending current; then the air chimney is supposed to drift with the general air current. As it drifts toward lower latitudes centrifugal force is supposed to give it an anticlockwise whirl in the northern hemisphere and a clockwise whirl in the southern hemisphere. But nearly every great cyclonic whirl is followed by a great anti-cyclonic whirl turning in the opposite direction, so what becomes of the centrifugal force theory as an explanation of the direction of these supposedly independent whirls?

We believe that barometric pressure differences are the effects and not the causes of most air currents. The air at times is heavily charged with electrons, and in that condition its electrons rotate around magnetic lines of force. Thus are both the permanent and the migratory cyclonic whirls created. An anticyclone is the descending end of a U-shaped air-whirl of which a cyclone is the ascending end. We believe that practically all air movements are due to such whirls. Migrating cyclones push air in front of them, acting like pistons. Stationary cyclones draw air inward, whereas stationary anticyclones expel air. The great system of air currents is generated by electronic forces and not by barometric pressure differences.

Not until the convection theory is completely displaced by the electron theory will long-range weather forecasting become possible. Long-range forecasting has been the real goal of meteorologists for two centuries, but the old false theory has latterly made that goal seem unattainable for many a century yet to come.

Man's Most Important Invention

Perhaps the most important of all inventions is the wheel and axle. The earliest records of wheeled vehicles are Egyptian. It is possible that the Chinese wheel-barrow was invented prior to the Egyptian two-wheel car or chariot.

Since mountain roads in Egypt were often only 4 ft. wide, their cars must have been very narrow. In going through Pompeii one is impressed by the exceeding narrowness of the streets, and especially of the parts that formed the roadway for chariots. In most instances this roadway is wide enough for only one narrow vehicle. At a street intersection there are high stepping stones, one of which is between the grooves worn in the pavement by the wheels, this stone being high enough to avoid stepping in the muck that probably existed in the trackway, but low enough to clear the axles of the chariots and carts.

In Naples, even today, two-wheel carts predominate, which probably indicates that four-wheel vehicles, at least for trucking purposes, are relatively modern.

In China there is only an insignificant mileage of roads wide enough for the use of motor cars. Narrow as were most of the Egyptian and Roman roadways for vehicles, those of China were narrower, probably because horses were not used. Even now the horse is not commonly used in China. China will doubtless pass directly from man-power to gasoline-power in vehicle propulsion, but the change will be rendered exceptionally difficult because of the narrowness of the roadways.

Flanged wheels on iron rails were first used about the year 1800, the invention being that of William Jessop of England. This marked the next great invention associated with the wheel and axle.

Next came an invention of supreme importance, the pneumatic tire. In 1843 an English civil engineer named R. W. Thompson patented this device for use on horse-drawn vehicles. It was never much used until the advent of "the safety bicycle" about 40 years later.

"The ball-bearing, invented by an Englishman named Bonn, is another epoch-making invention," says the Encyclopedia Americana under Bicycle, although it fails to list this important invention under Inventions where a chronology is given of the most important inventions since 1620. Incidentally it may be added that no biographical sketch of Bonn, Thompson or Jessop is to be found in either the Americana or the Britannica. Hence three of the most important inventors in the history of the wheel have received no biographical recognition by the two most commonly used encyclopedias. When these omissions are contrasted with the thousands of biographical sketches of men who did nothing but talk, one is impressed with the idea that the talkers still rank higher than the doers in the estimation of the encyclopediaists.

Not long ago we had occasion to look for a sketch of the German who invented wood-pulp paper, but could not find it. He may have got his great idea from examining wasps' nests, as the story goes, but since no other human-being in the long history of mankind had wit enough to take an industrial hint from those fiery but ingenious insects, one would expect at least an inch of typed information in the encyclopedias about that man.

H. P. Gillette

WATER & WORKS SEWERAGE

Design ~ Construction ~ Collection
Treatment ~ Distribution ~ Disposal

September, 1930 — H. P. Gillette Editor — Vol. LXXVII. No. 9

O'Shaughnessy Dam and Hetch Hetchy Reservoir, Hetch Hetchy Water Supply, City of San Francisco, Calif.

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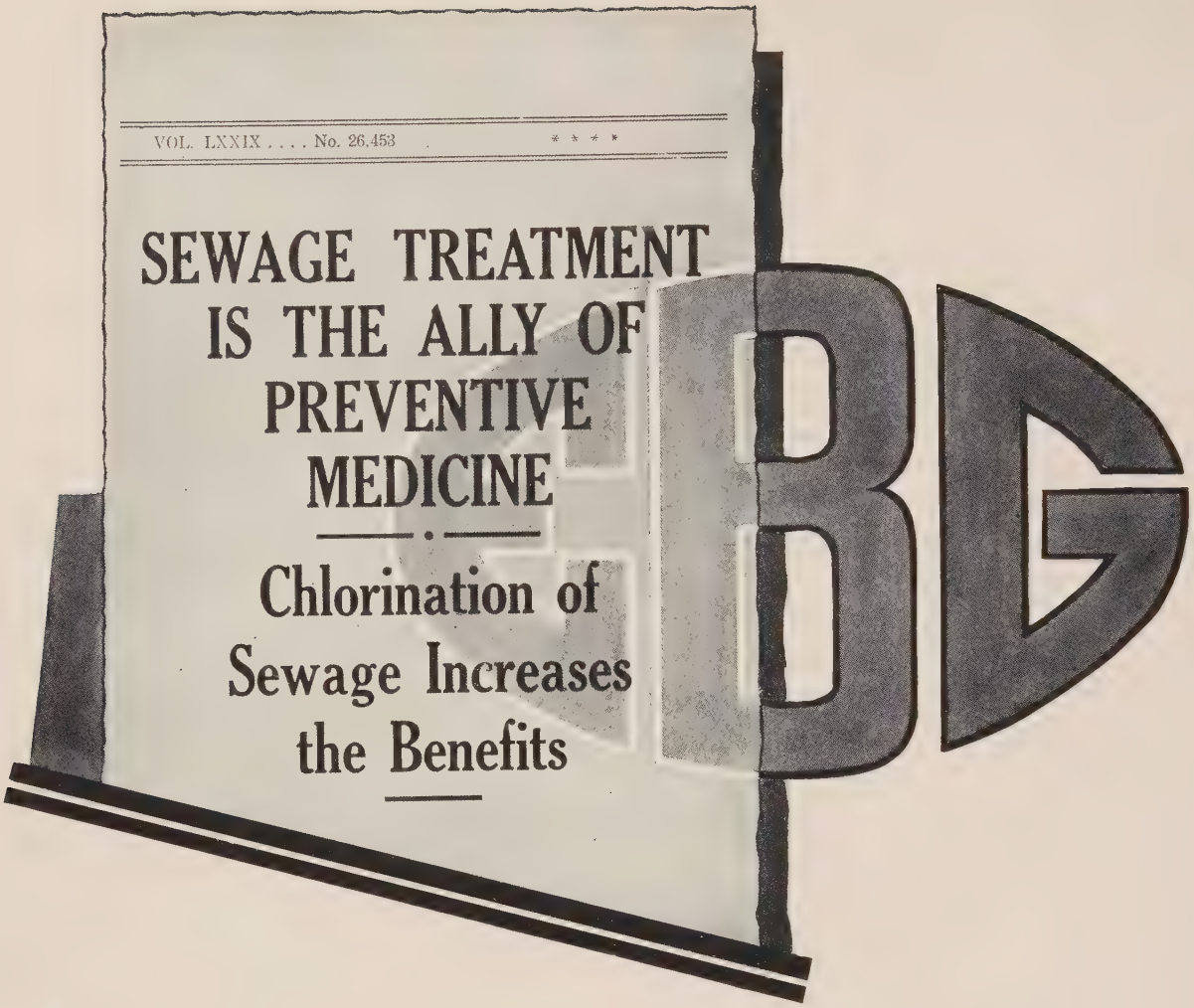

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Water Works and Sewerage

H. P. GILLETTE, Editor

Vol. LXXVII SEPTEMBER, 1930 No. 9

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Water Works and Sewerage

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Lake Eleanor Dam of San Francisco Water Supply

The Hetch Hetchy Water and Power Project

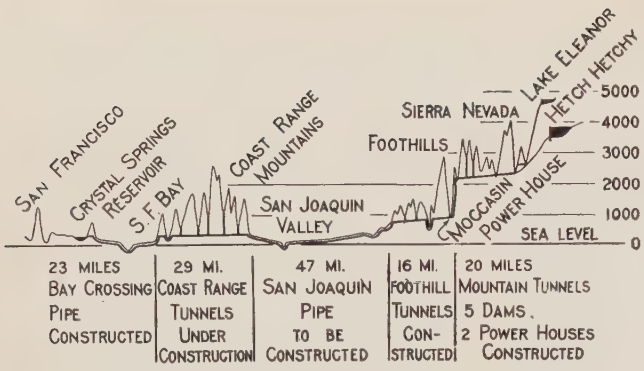
City of San Francisco Anticipates Completion by 1933—Driving and Lining of Coast Range Tunnel Expected to Be Completed in 1932—Work on Coast Range Tunnel Described—San Joaquin Valley Pipe Line to Be Begun in 1931—New Water Department Organized by City

By M. M. O'SHAUGHNESSY
City Engineer, San Francisco, Calif.

CONSTRUCTION is proceeding satisfactorily on San Francisco's mountain water and power project, on a schedule aiming at completion by 1933. The controlling schedule has been to construct the revenue-producing units as soon as possible and then to complete the aqueduct before the existing local water supply shall have become inadequate for the city's needs.

Working under this program the two ends of the system were completed first. The storage reservoirs at Hetch Hetchy and Lake Eleanor, with the Sierra Nevada tunnels and Moccasin power house are producing hydro-electric energy which is distributed in the city through the agency of a public service corporation to net the water project $2,000,000 annually. The Bay Crossing pipe line has been in use on a rental basis, carrying water from the East Bay sources of the Spring Valley Water Co. to the reservoirs on the San Francisco Peninsula. While operation of these producing units has been carried on, construction of the three remaining divisions of the aqueduct has been pushed.

The Foothill tunnel, 15.8 miles in length, from Moccasin power house to the San Joaquin valley, was completed in 1929. This tunnel consists of about 8¼ miles of 10-ft. 3-in. concrete-lined section and about 7.5 miles of 13-ft. 4-in. by 14-ft. 3-in. unlined, arch-top section.



Status of Hetch Hetchy Water Supply, 1930

The constancy of volume of flow in the aqueduct is disturbed by the varying load in the Moccasin power house, so re-regulation of the flow is necessary after leaving the tailrace. A re-regulating reservoir was provided by building a dam (the sixth on the project) across Moccasin Creek. This structure, completed early in 1930, is of rolled earth and rock fill with concrete core wall and rubble upstream face. The dam is 850 ft. long and 51 ft. high with crest at El. 927, and contains 143,000 cu. yd. of fill and 3,600 cu. yd. of concrete. It forms a reservoir of 648 acre-feet capacity, from which the water enters the tunnel.

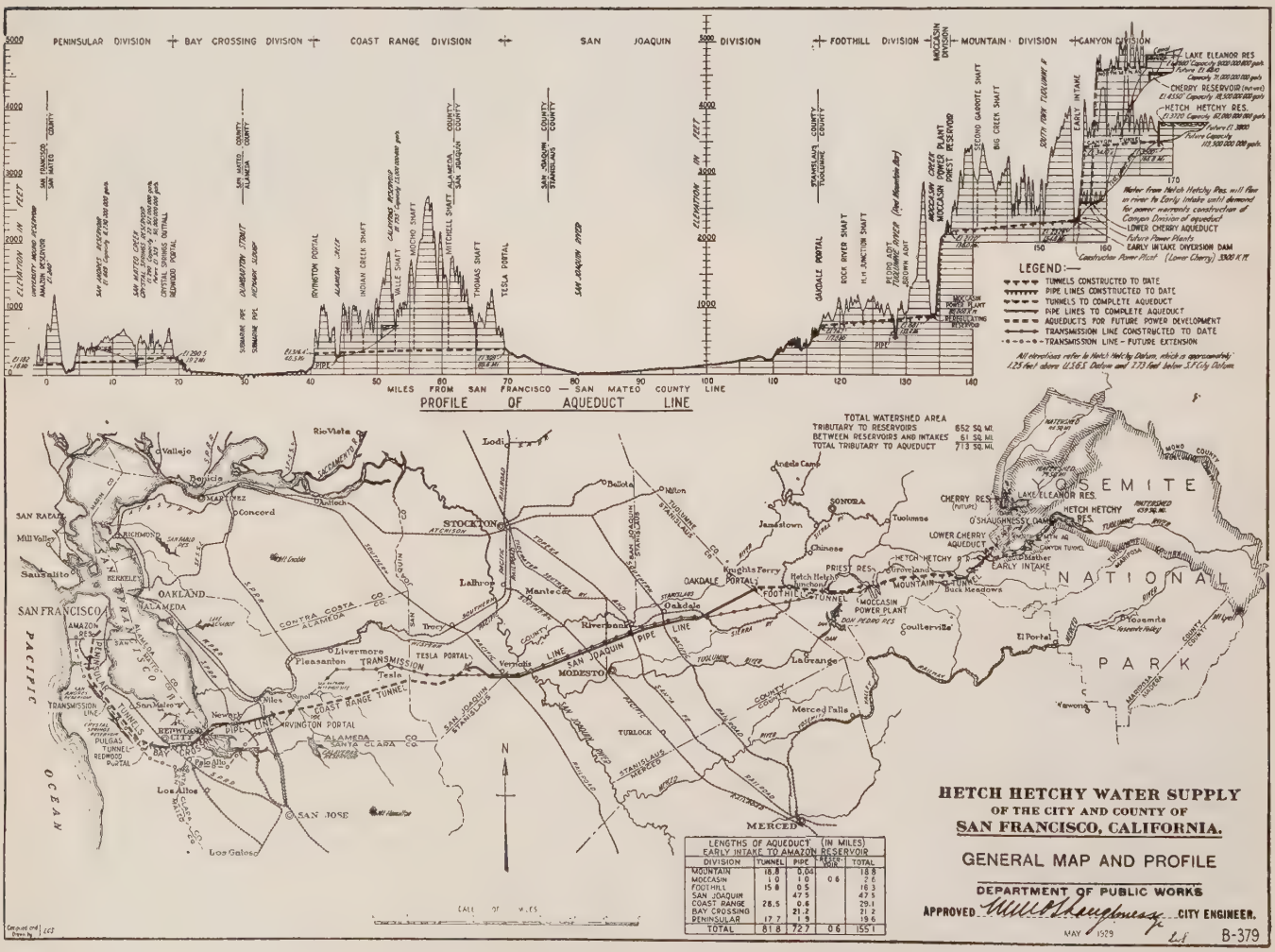
At Red Mountain Bar, 5 miles from Moccasin, the aqueduct crosses under Don Pedro reservoir in the canyon of Tuolumne River as riveted steel pipe 9 ft. 6 in. in diameter, laid in trench blasted out of the hard bedrock. The pipe is lined inside with cement mortar and is covered with an envelope of concrete from 18 in. to 2 ft. thick.

At this point the city contemplates erecting another power house. This plant, for an investment of $1,000,000, could produce power valued at $500,000 annually.

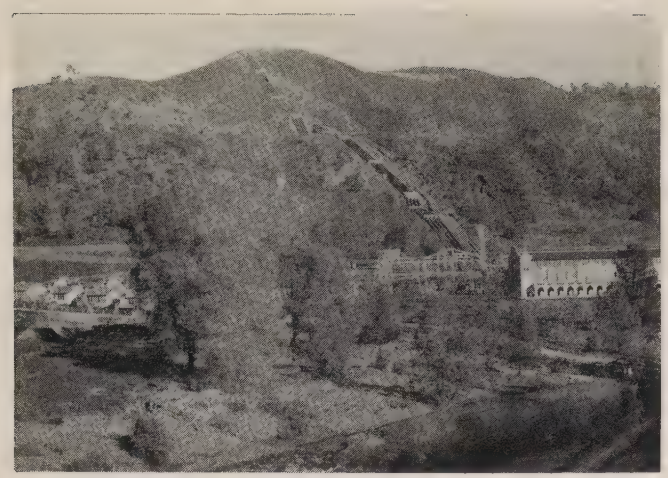
From the end of the Foothill tunnel, there will be a 47-mile pipe line across the San Joaquin valley. The pipe will follow along the city's present power transmission line in a 110-ft. strip already acquired. Bids for this pipe work will be taken early in 1931 so as to complete the work at the same time as the tunnel through the Coast Range, which is now under construction.

The aqueduct pierces the Coast Range, of which Mt. Hamilton and Mt. Diablo are prominent peaks, as a tunnel 28.6 miles in length. The easterly portal of this tunnel is the terminus of the San Joaquin pipe line. The westerly portal will require 1.3 miles of pipe to connect it to the existing Bay Crossing pipe. The tunnel is continuous for 25 miles to Sunol valley, which will be crossed by 0.6 miles of pipe.

In the 25-mile section of Coast Range tunnel, five construction shafts were sunk, two of which are over 800 ft. in depth. The tunnel is driven from four portals and both east and west from each shaft, or in 14 headings. At present 1,200 men are employed on this division and progress of almost 1 mile per month is being made. It is expected that the driving and lining will be completed in 1932, along with the pipe



General Map and Profile, Hetch Hetchy Water Supply



Left—Moccasion Power Plant. Right—Interior of Power House. Head, 1,316 Ft.; Total Capacity, 100,000 Hp.; Four Generators with Double Overhung Pelton Wheels

construction noted above, so that the entire aqueduct will be ready to conduct the pure mountain water by Jan. 1, 1933, to fill the peninsular storage reservoirs recently acquired by the city from the Spring Valley Water Co.

Although the tunnels previously constructed have been built to a capacity in excess of 620 sec.-ft., or 400 m.g.d., economic studies indicated the advisability of building this tunnel on the installment plan. The present 10-ft. 6-in. diameter tunnel, on a flatter grade than the previous tunnels, will have a capacity of about 300 m.g.d., which will be sufficient for many years. A future parallel tunnel of equal capacity may be constructed when necessary. The compounded saving in cost of the present smaller tunnel as against a present full-capacity tunnel is estimated at $8,000,000 or greater.

The shafts sunk are on the center-line of the double aqueduct. The long axis of each shaft, which is 6 ft. 9 in. by 20 ft. (overall dimensions) is at right angles to the aqueduct center. Parallel to the axis a crosscut, generally 14 ft. in clear diameter, is driven 95 ft. north to the center-line of the present tunnel and 90 ft. south to the future tunnel. Short stub ends of the future tunnel serve for car storage, electrical equipment, etc. Pumps are installed in the crosscut. Shaft and crosscut are lined with concrete to permit their use for construction of the future tunnel.

Excavation is by the usual methods, either drilling and blasting, or by air spades if the material is soft. The spoil is loaded by air-operated mucking machines into steel cars which are hauled by storage-battery locomotives. The muck is hoisted from the shaft rock pockets and automatically dumped at the surface.

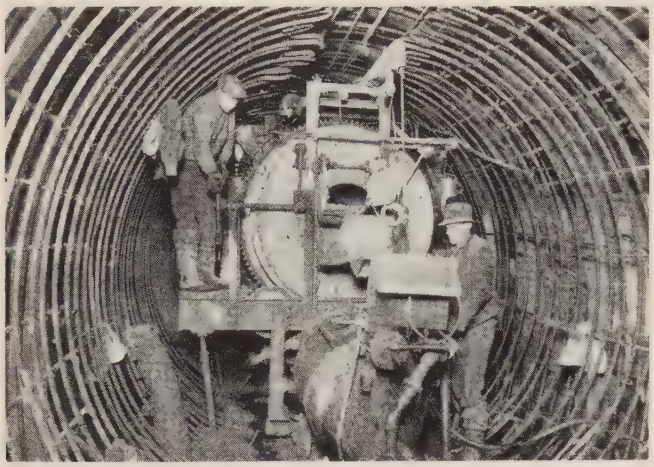
Lining will be placed by concrete gun. Gravel and sand will be obtained from nearby supplies which are now being developed. In some parts of the tunnel, the existence of swelling ground has necessitated immediate placing of concrete lining to prevent air-slacking. Such emergency lining is placed by cement gun.

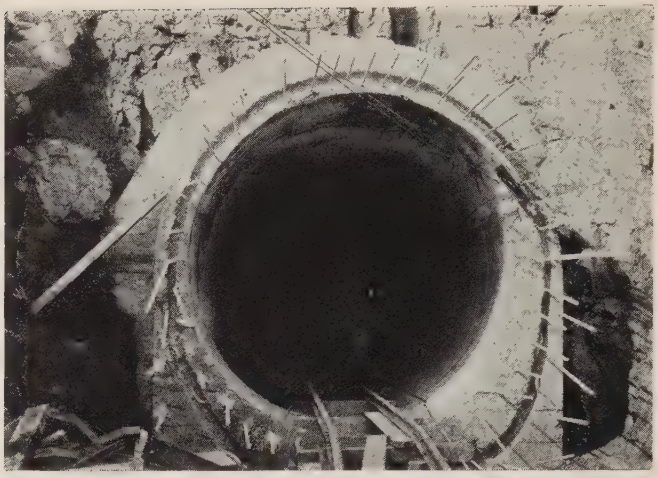
Occasional water-bearing seams are encountered. One of these, in sandstone, carried a flow of 2,500 g.p.m., which decreased to 1,000 g.p.m. Such seams are filled by grouting in the usual manner. The grouting operation is not difficult, but always causes considerable loss of time in carrying on the tunnel driving.

Fossiliferous and coal-bearing strata have been encountered and elaborate precautions have been taken to guard against explosion from pockets of methane and sulphuretted hydrogen gas. The present aqueduct location was selected after extensive geological studies and diamond-drill borings aggregating 5,014 ft. The abandoned Tesla coal mines, two miles north of the route gave indications of difficulties to be encountered as far as possible in view of the necessity of keeping the depths of shafts within a reasonable figure.

In over 28 miles the aqueduct deviates only ½ mile

Left—Interior of Priest Tunnel (Mountain Division). Right—Face of Priest Tunnel, 500 Ft. In.





Left—Pedro Adit, Foothill Tunnel; Concrete Mixer and Gun Place Concrete in 10-Ft. 3 In. Reinforced Circular Section. Right—Red Mountain Bar West Portal

from a straight line. The longest distance between shafts is 5.2 miles, which is justified by the city's experience in previous tunnel work.

Consideration was given to the practicability of an alternative route over the summit with a 60-m.g.d. temporary pipe line and pumping stations, but economic studies indicated a preference for the pressure tunnel.

Local storage and distribution for the mountain water will be provided by the facilities of the system of the Spring Valley Water Co., which was recently acquired by the city, the operation of which is vested in the newly created water department. The acquisition, on March 3, 1930, of this property brings the city 62,000 acres of watershed and reservoir lands, five impounding reservoirs with capacity aggregating 65 billion gallons, a well system and infiltration gallery, 111 miles of main aqueduct with several pumping stations, a distribution system of 20 reservoirs and tanks with 750 miles of pipe and pumping stations delivering water up to 800 ft. elevation, all riparian and other rights necessary to impound and divert the waters and over 105,000 consumers.

The local system has been estimated as sufficient to yield 65 m.g.d. or greater, but during a succession of seven or eight seasons of scant rainfall, it has been stressed to supply the needs of the city, which now amount to 52 m.g.d. As a means of temporary relief until completion of the Hetch Hetchy aqueduct, the city is sinking 20 wells in the sandy area adjacent to the ocean beach, in the expectation of producing 6 m.g.d.

The purchase of the local system on March 3, 1930, cost the city $40,000,000. The Hetch Hetchy system, when completed within three years, will have cost nearly $80,000,000. By capitalizing the $2,000,000 net annual power income, this latter figure may well be divided into $40,000,000 for water construction and a like amount for power construction.

Design and construction of the Hetch Hetchy project are under M. M. O'Shaughnessy, city engineer, with L. T. McAfee as chief assistant and C. R. Rankin and L. A. McAtee as construction engineers. Former Chief Assistant Engineer N. A. Eckart is now manager of the new water department, in charge of operation of the local system.

•

Large Bronze Castings for New York Water Supply.—The largest single order for bronze castings placed since the World War has just been awarded the American Manganese Bronze Co. of Holmesburg, Philadelphia. The castings which are to be made of manganese bronze of the highest physical values obtainable total over one million pounds. They are to be used in connection with the new water supply for the City of New York.

Left—Crosscut from Indian Creek Shaft, Coast Range Tunnel. Right—Concrete and Steel Pipe Bridge 3,870 Ft. Long, Over Shallow Portion of San Francisco Bay at Dumbarton Strait. Flexible-Joint Cast-Iron Pipe Carries Line Under Navigable Channel

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Filtration Engineer, Bureau of Engineering, Chicago, Ill.

The Taste Problem Solved

THREE years ago had some one predicted that the taste problem would be solved within three years most of us would have thought it impossible. Yet this is what has taken place within that time. Such rapid advances have been made in the development of treatments for the elimination of taste from water that within the very near future there should be no excuse for any water plant, except in very unusual cases, delivering water to the public with an objectionable taste. Taste as used in this article is intended to include both tastes and odors.

The perfection of methods for the elimination of taste from water constitutes the greatest advance made in water treatment since the introduction of filtration and chlorination. Nothing is going to produce greater confidence on the part of the public in the ability of the water chemists and engineers to treat water properly than the production of water free from taste. Just as we have confidence in the astronomer because he can calculate with exactness the time of an eclipse of the sun or moon, so will the public have greater faith in our work because we can produce palatable water. To say that the water is safe when it contains very disagreeable tastes, leaves doubt in the minds of most people. Many filtration plants have been greatly discredited because the water is not palatable all the time.

The following is from an editorial which appeared in one of the Chicago papers shortly after a modern filtration plant was put in operation in one of the nearby cities:

"————, a progressive city to the north of us, has made the experiment. Although only recently constructed, it is declared a failure so far as helping the taste. The city's million-and-a-half-dollar pumping station and filtration plant just opened and designed to produce better tasting water failed to do so.

"For more than twenty years ———— had argued about a filtration plant. The one just opened was hailed as the most modern and efficient in the middle west. It was constructed because ———— residents grumbled about paying increased water rents for unpalatable water.

"The water problem probably could be remedied by prohibiting the dumping of phenol wastes in the lake which would be much easier and cheaper than constructing useless filtration plants."

In so far as the clarity of the filtered water in this city was concerned, it was excellent, but the public wanted and expected water free from objectionable tastes and were not getting it. The number of filtration plant operators who, within the past summer, have sought the aid of the writer in their taste problem has been quite large. This indicates that many water supplies are below what they should be in palatableness, at least part of the time. The bottled water companies continue to flourish in a number of cities in which the water is filtered. Not long ago a representative of one of the large bottled water companies of the middle west was asked if he feared a loss of business in a certain city if filtration plants were constructed. He said no, that they had continued to do a large business in a near-by city which had filtered water, because the bottled water was more palatable than the filtered water.

We might attribute a small bottled water business in any city as being due to the peculiar ideas of some people, but a large business indicates that the bottled water is more palatable than the city water. Until the water purification chemists can produce water which is the equal in palatableness of bottled water, they should expect the bottled water companies to flourish. The water chemists have not remained idle, and the accomplishment within the past three years along this line speaks for itself. Early attempts to eliminate taste were along the lines of aeration and prevention of pollution, and it is only recently that the problem has made headway along chemical lines. Now let us see how it is being attacked and what is being accomplished.

It is believed that aeration, where the sole function is to throw off offensive gases into the air, may be eliminated from consideration. This is not to convey the impression that aeration has no value in water treatment, but as a taste elimination process it has been only moderately successful. That it is helpful in many instances, there is no doubt, but there are very few tastes that can be eliminated by this process to the extent that they cannot be detected, especially if the taste before aeration is very pronounced. Where water is deficient in dissolved oxygen it is evident that aeration is the cheapest means of restoring the oxygen; also it is evident if the water is high in carbon dioxide that it may be reduced materially by aeration.

Recent efforts in taste elimination have been along two lines. One is to prevent the taste being made more pronounced when chlorine is added to the water, and the other is to eliminate all objectionable tastes by removing them from the water or by changing them to inoffensive compounds. Where the chloro tastes are the only objectionable tastes, processes that prevent the formation of these compounds are satisfactory, but for a large number of waters the prevention of the chloro tastes only is not going to solve the taste problem.

The Superchlorination Treatment.—The addition of chlorine to water produces a strong oxidizing agent. Many of the taste-producing compounds can be broken down, or changed to inoffensive compounds by the nascent oxygen of the hypochlorous acid. With the small amount of chlorine usually added to water for sterilization, the concentration of residual chlorine is

not sufficient to bring about the oxidation of these offensive compounds. When enough chlorine is added to bring about the desired chemical reaction, considerable residual chlorine is left in the water and this will produce a disagreeable chlorine taste. There are several ways of dechlorinating water, which will be discussed later.

Sir Alexander Houston in his 1920 annual report on the London water supply pointed out the possibility of removing certain tastes by using an excess of chlorine. Brush[1] describes experiments made in January, 1922, on the use of an excess of chlorine to destroy the "ripe cucumber" or "fishy" taste in the Catskill water of the New York water supply caused by the presence of synura. About 0.70 p. p. m. of chlorine was used. The organisms decreased shortly afterwards, and there was no need for continuing it, but the treatment was regarded as a success. Howard[2] at Toronto was the first to make extensive use of the superchlorination treatment solely for the purpose of eliminating taste. Superchlorination followed by dechlorination with sulphur dioxide was first started at Toronto on Sept. 2, 1926. Howard reports the elimination of practically all taste by this treatment. The maximum dose of chlorine applied during the superchlorination treatment was 2.5 p. p. m., and the minimum dose, 0.8 p. p. m. Hale (*Water Works Engineering*, vol. 83, p. 1173, July 30, 1930) describes the successful use of superchlorination followed by dechlorination with sulphur dioxide to remove tastes caused by organic pollution of well water. Prechlorination is now being practiced at a number of filtration plants, and while enough chlorine probably is being added in a few instances to help in oxidizing the taste-producing compounds, in most instances enough is not being added to call the treatment a superchlorination treatment.

The success of the superchlorination treatment depends upon the power of the chlorine to break down the offensive compounds and also upon the effectiveness of the dechlorinating process. It so happens that the most commonly occurring tastes such as are produced by microörganisms and by the phenolic compounds are readily changed to inoffensive compounds when treated with a certain excess of chlorine. The water one hour after treatment should have from 0.5 to 1.5 p. p. m. of residual chlorine, depending upon the nature and the concentration of the taste-producing compounds. The taste in probably 95 per cent of the water supplies can be lessened or completely eliminated by the superchlorination treatment if the excess chlorine is later removed.

The addition of a strong oxidizing agent in excess to water has an advantage in that all bacterial life, regardless of how abundant, is killed and there can be no doubt as to the safety of the water. The oxidizable organic matter is reduced, and the water is more likely to remain stable when stored than if it contains a large amount of such matter. The main reason why superchlorination has not made greater headway has been the fear of the operator that he cannot at all times completely dechlorinate the water. Not that dechlorinating agents are ineffective at times, but the difficulty in securing an application of the dechlorinating agent in proportion to the residual chlorine present, when the residual is known to vary with fluctuating conditions of the water with constant application, has made many operators hesitate to try this treatment.

Dechlorination with Sulphur Dioxide.—Sulphur dioxide is a very effective dechlorinating agent. It is obtained as a liquid under pressure, and has to be handled in much the same manner as chlorine. The reaction is as follows:

$$SO_2 + H_2O = H_2SO_3$$
$$H_2SO_3 + OHCl = H_2SO_4 + HCl$$

Theoretically it requires about 0.9 lb. of sulphur dioxide to dechlorinate 1 lb. of residual chlorine. In practice it has been found best to add about the same amount of sulphur dioxide as the residual chlorine. Howard was the first to use sulphur dioxide for dechlorination on a large scale. In a paper presented before the Water Purification Division of the American Water Works Association at the St. Louis convention, June, 1930, on progress in the superchlorination treatment for taste prevention at Toronto, Howard regards the treatment as highly successful. He also describes the equipment necessary for handling the sulphur dioxide. In this same paper Howard stated that an occasional musty taste has occurred in the water following superchlorination, and that research work carried out at Rotterdam, Holland, showed that the addition of a chlorophenolic solution to river water produced a musty taste after filtration, which later was removed by passing the water over Norite activated carbon.

Dechlorination with Sodium Bisulphite.—This compound ($NaHSO_3$) may be purchased in the powdered form, and is readily soluble in water. Its dechlorinating properties depend upon the SO_2 present in the compound. The reaction is

$$2NaHSO_3 + 2OHCl = Na_2SO_4 + H_2SO_4 + 2HCl.$$

L. I. Birdsall, of the General Chemical Co., is believed to be the first to use this material for dechlorination, though its dechlorinating properties were well known. Its first use was at the Glencoe, Ill., filtration plant in July, 1930. It was used for dechlorinating the water that was superchlorinated to remove a fishy taste. About 1.5 lb. of sodium bisulphite are required to dechlorinate 1 lb. of residual chlorine.

The Chlorine-Activated Carbon Treatment.—Experimental work indicates that the chlorine-activated carbon treatment is the most successful of any of the treatments for the elimination of practically all objectionable tastes from water. It combines all the advantages of a strong oxidizing compound with material having the power to absorb most of the taste-producing compounds. So far, no taste likely to be present in water has been found that cannot be removed by this treatment. It will be only in very unusual cases that a taste will be found that cannot be removed.

The water is superchlorinated, preferably at the beginning of the treatment process, to the extent that there is a large excess of chlorine after filtration, or just before it is dechlorinated. Up to this point it is merely the superchlorination process. In most instances a residual of about 0.5 to 1.0 p. p. m. of chlorine just prior to dechlorination will be sufficient, especially if there has been 3 to 4 hours' contact time. For some waters a residual greater than 1.0 p. p. m. may be required, but very likely no condition will require a residual greater than 2.0 p. p. m. Now these figures may astound some of the filtration plant operators who have been accustomed to working with residual chlorine figures ranging from 0.00 to 0.20, and under instruction not to let the residual exceed 0.20 for fear of producing a chlorine taste. No doubt they will at first fear that so great an increase over their usual dosage will occasionally produce taste due to some mishap in the treatment process. The effectiveness of the dechlorinating process is one of the chief merits of the

chlorine-activated carbon method. It is almost a foolproof installation, and can be made to work about as effectively in a small plant where there is no technical supervision as in a large plant where there is the best of supervision. About all that is required of the operator is to know how to make residual chlorine tests.

The fact that charcoal, lignite, activated carbon, etc., will dechlorinate water has been known for a number of years. The Candy Filter Co., of England, made use of this process about 20 years ago[3]. They probably used an active carbon at first and later changed to raw lignite, for we find that Frank Candy and Frank Pullen Candy applied for a British patent July 23, 1915, on the use of raw lignite. Patent No. 10,705 was granted July 20, 1916. The following from the specifications in the patent may be of interest in view of the fact that more recent patents have been issued on the use of activated carbon for dechlorination:

> In carrying our invention into effect we first add to the water a bacterial dose of free or available chlorine (which we will speak of as "free chlorine") and, after allowing sufficient time for the due action of the free chlorine upon the bacterial impurities of the water, we bring the same, still containing free chlorine, in contact with lignite, preferably by passing the chlorinated water through a bed containing granulated lignite; we have discovered that the lignite possesses remarkable properties in eliminating or fixing the free chlorine and is much more effective for this purpose than carbonized lignite which we have previously used.
>
> The quantity of free chlorine we generally employ, for drinking water of an average chemical purity, is one part to one million parts of water and the thickness of the layer of lignite we use when passing the treated water through it at the rate of about 150 gal. to each square foot of filtered bed area per hour is about 18 in. We granulate and sift the lignite to produce fragments of suitable size for our purpose.
>
> We preferably place a layer of sand under the layer of lignite and arrange the whole so as to give free drainage or passage of the water therefrom.
>
> We generally allow a period of about half an hour for contact between the free chlorine and the water before subjecting the same to the dechlorinating action of lignite.

This should be of particular interest as it is almost the same as is used today, except that activated carbon is preferred to the raw lignite due to its high adsorbtive properties. Also it has been found that for most waters a higher dose of chlorine is desirable, and that deeper beds of carbon are better. This patent refers to the previous use of carbonized lignite, which indicates that active carbon was used prior to the raw lignite.

Just why the Candy inventions did not attract more attention at that time probably was due largely to the fact that filtration engineers and chemists were not willing to admit, or did not know, that chlorine had a value other than a sterilizing agent, and they were striving to keep its use down to a minimum by making filtration as effective as possible. Candy apparently abandoned the use of an adsorbing carbon for material that merely dechlorinated the water, and while it dechlorinated the water all right it probably was not very successful for taste elimination under the conditions in which it was used. Had a little more study and experimentation been given to the use of active carbons in water treatment at that time we might have been much more advanced in taste elimination than we are today. The prevailing opinion 15 to 20 years ago was that if a little chlorine produced a disagreeable taste a larger amount would make the taste still more pronounced. In fact our attention was focused on the sterilization of water at that time and little thought was given to taste removal.

About the time filtration chemists and engineers were becoming fully convinced that some effort must be made to reduce the objectionable tastes that occurred in many waters to meet the demands of the public for more palatable drinking water, and began to study taste elimination methods, the experiment on activated carbon was started at Cleveland. The report of the Cleveland work at this writing has not been made public, but according to rumors the carbon was not a success. This has done a great deal to discourage the use of activated carbon. If the experiments were not a success it must have been due to the kind of material used or the manner in which they were conducted, for the right kind of material undoubtedly would have been a success if tried along conservative lines.

A publication of the essential facts of the Cleveland report would do much to clarify the situation, for very likely there would be no difficulty in showing wherein the materials or the procedure was at fault, if the report shows carbon to be a failure as the rumor is circulated. Sometimes we find considerable difference between rumors and the actual facts. This should not be construed as criticizing the taste prevention treatment which has been adopted at Cleveland. If the ammonia-chlorine treatment completely eliminates all tastes at Cleveland and produces the ideal tasting water, then there can be no criticism of this treatment being adopted.

Rapid progress in an experimental way is being made on the use of activated carbon in water treatment. Suitable types of carbons have been developed, and the requirements for their successful use have been worked out fairly well. Recent publications both in Germany and the United States give considerable information on the subject. Imhoff and Sierp[4] describe successful experiments on the elimination of taste, first with an experimental unit containing 20 liters of activated carbon; then on a plant scale for treating 25,000 cubic meters (about 6,600,000) gal. of water daily, where the taste trouble has been prevalent for years. The treatment in addition to removing the phenols has also removed earthy, musty odors from the water. This article was translated by Dr. Buswell, and published in the August, 1929, issue of *Public Works,* pp. 308-309. Sierp[5] gives a summary of the literature on the cause and prevention of smell and taste in drinking water, and states that a large amount of chlorine, given a long contact time and then removed, leaves no taste. Sodium thiosulphate or sulphur dioxide will remove the chlorine. An active carbon filter is sufficient without excess chlorination. It has been found to remove not only chlorophenol taste, but other tastes arising from algae or mineral matter.

Adler[6] adds a large amount of chlorine to the water and then passes the water over activated carbon to convert the chlorine to hydrochloric acid. From time to time the carbon must be washed with water containing sodium carbonate to remove the organic material from the surface. Jotten, Sartorius and Ottemeyer[7] state that charcoal is well adapted to the removal of taste, turbidity, etc. They found that activated charcoal was much better for removing phenol than wood charcoal or coke. Koenig[8] conducted experiments to find the best means of treating the Elbe water for Magdeburg. Chlorination of the raw water showed advantages in algae destruction, decrease in bacterial growths and longer filter runs, but odor and taste were not removed. Activated carbon, alum and marble calcium hydroxide were added in this order before the primary filters. The adsorbtive effect of the carbon was impaired by the formation of a coating of aluminum hydroxide. The most satisfactory results were obtained by treating the water before the primary

filters with filter alum and fuller's earth with subsequent activated carbon filtration. The final effluent was free from color, taste and odor.

In the year book for water chemists and sanitary engineers, Vol. 3, Verlag Chemie G. M. B. H. Berlin W 10., R. Engler gives an account of the operating experiences at the experimental Stuttgart water works in purification of surface water containing humic acid. Taste was removed with active carbon. In the same publication, H. Pick describes the dechlorination of water with active carbon. Dechlorination follows the equation of mono-molecular reactions. Regeneration was accomplished with a solution of 5 per cent sodium hydroxide, but it is better to heat to 200 to 500 deg. C.

The writer[9] presented a paper before the Water Purification Division of the American Water Works Association at the Toronto convention in June, 1929, on the activated carbons and their use in removing objectionable tastes and odors from water. The work on activated carbons at the Chicago experimental filtration plant was described. A unit having 10 sq. ft. of surface area and 24 in. of 4 to 12-mesh Hydrodarco is being run at a rate of 2 gal. per sq. ft. per minute. Spalding[10] describes the successful use of pulverized Nuchar by adding it to the water and later removing by filtration. The taste was removed by this procedure. He also describes the removal of taste caused by aldehol contamination, which was not removed entirely by superchlorination.

Behrman and Crane presented an excellent paper before the Water Purification Division of the American Water Works Association at the St. Louis convention in June, 1930, on the chemical and mechanical utilization of activated carbon in water treatment. They gave a description of units suitable for passing water through beds of Hydrodarco as manufactured by the International Filter Co., and many other details regarding the practical utilization of carbon. At this same meeting, George D. Norcom gave results of an interesting series of experiments conducted with carbon on the water supply for Chester, Pa. This paper was published in Water Works and Sewerage, August, 1930, p. 269. The water is polluted by a variety of industrial wastes. Hydrodarco removed all the tastes and odors from the water for the duration of the experiments, which lasted several months. Passing steam through the carbon partially revivified it. Also at this meeting the writer brought his experiments at Chicago up to date. The carbon unit started in December, 1928, is still giving satisfactory service.

Thus we can see that there has been sufficient experimentation on the superchlorination treatment combined with dechlorination with activated carbon to give the promise of extensive use of the process in the future. There can be no question as to the effectiveness of the chlorine-activated carbon treatment in practically all waters. The only question is whether a cheaper and equally effective treatment may be found. To give details on the practical application of carbon in water treatment would make the present article too long. Apparently the only disadvantage is the first cost. There are indications that it will add 5 to 10 per cent to the plant cost for new treatment plants and somewhat more for plants already constructed.

The cost of the carbon should be charged to operating expenses, but the units have to be filled with carbon at the start. With fairly good water that has only an occasional taste, the cost of eliminating the taste should not exceed $1 per m. g., and for highly polluted water the cost will vary from about $1.50 to about $3.00 per m. g. The cost of the carbon, the cost of revivification and the number of times it has to be revivified will have considerable influence on the cost of the treatment. The carbon used for color removal in sugar refineries is revivified many times before it has to be discarded, giving indication that this may also be the case in water treatment. The writer is of the opinion that it is economy to do as much of the taste elimination as possible with chlorine, and use the carbon for removing the excess chlorine and compounds not broken down by the chlorine. The reaction of the chlorine with the carbon is a direct chemical action and there is no necessity for frequent revivification.

Adsorption by Activated Carbon.—The use of activated carbon as above described is in connection with chlorine, and allows the chlorine to do all it will towards breaking down the taste-producing compounds before the water reaches the carbon. The carbon then removes by adsorption such offensive compounds as are not changed by the chlorine, and also the residual chlorine. Experiments on the use of activated carbon without the use of chlorine indicate that most, if not all the taste-producing compounds, may be removed by adsorption. The literature on the characteristics of the activated carbons and their use in the industries is quite extensive. We are more familiar with their use in gas masks during the world war, and their use in the sugar industry. The reader is referred to articles by Strachan[11], Chaney, Ray and St. John[12], Bartell and Miller[13], Miller[14], Horton[15], Lamb, Wilson and Chaney[16], and Mantell[17].

The number of compounds that may be removed from water by adsorption with activated carbon is fairly large. No one has attempted to determine all the compounds, but it seems that practically all taste-producing compounds that are likely to occur in water may be removed in this manner. Adsorption may be distinguished from a direct chemical reaction in that the surface carbon atoms do not turn loose their bond with the interior atoms of the carbon, but remain fixed and attract the adsorbed substances to the surface of the carbon with sufficient force to hold them on the surface. The effectiveness of a material is dependent upon its carbon content, the surface area and perhaps other characteristics not so well understood. While its use in water treatment is largely in the granular form, the granules themselves must be very porous and have an enormous surface area for a given volume of the material. The surface area of a 1-in. solid cube is 6 sq. in., whereas the surface area of a porous substance such as an activated carbon may be several million square inches for each cubic inch of the material. This is why it is essential to keep the pores of the granules of carbon open. Anything that stops up the pores greatly reduces the adsorptive capacity of the carbon.

Kolthoff and Van Der Goot[18] have made probably the most extensive study of the hydroxybenzenes and other aromatic compounds that are adsorbed by carbon. They give the values for $\frac{1}{n}$ and $\propto$ in the Freundlich adsorption equation $\frac{x}{m} = \propto C_2^{\frac{1}{n}}$ for a number of such compounds, using "carbo merk" for the active carbon. The fraction $\frac{x}{m}$ represents the millimoles of the com-

pound adsorbed by 1 gram of air dry carbon. $\frac{1}{n}$ and $\propto$ are constants that have to be determined for each material adsorbed and for each brand of carbon. C_2 is the concentration of the material in moles remaining in solution. Table I gives the values of these constants as determined by Kolthoff and Van Der Goot.

We do not have much information at the present time as to how often activated carbon will have to be revivified when used without chlorine. There are indications that it will have to be more frequently than when used in connection with chlorine, for the chlorine seems to help keep the material active.

It might be well to call attention to the fact that the constants in Table I were determined from results recorded in moles or millimoles of the compound adsorbed and remaining in solution. The writer's results as given in a previous article were recorded in parts per million and parts per billion. For those who are not so familiar with chemical terms, it might be well to state that all compounds given in the list are readily adsorbed by activated carbon. The table does not give the entire list of taste-producing compounds that may be present in water. In so far as the writer knows, the compounds responsible for algae or fishy taste in water are not known.

All carbons that dechlorinate do not have high adsorptive properties. Table II shows comparison of the phenol adsorptive capacity of raw and carbonized lignite. The carbonized lignite used in the test was Hydrodarco, a material that is treated especially to make it highly adsorptive.

Assume that not more than one part per billion of phenol can remain in solution without causing chlorophenol tastes when chlorine is added, the raw lignite reduced to this figure a solution containing about 30 parts per billion of phenol whereas the Hydrodarco reduced to the same figure a solution containing 5,000 parts per billion of phenol. This shows the activated material to have an adsorptive capacity approximately 166 times that of raw material. The raw material dechlorinates very well but that is about all that can be said in its favor.

The Ammonia-Chlorine Treatment.—A taste elimination treatment now being promoted very actively is the addition of ammonia to the water prior to chlorine. The main function of this treatment is to prevent the formation of chloro tastes. The chlorine unites with the ammonia to form a chloramine which is a weak instead of a strong oxidizing agent. This compound does not readily oxidize the organic matter present in the water, which is directly opposite to the purpose of the superchlorination treatment, for the superchlorination treatment is applied to oxidize as much of the organic matter as possible. Some of the advantages of the ammonia-chlorine treatment, as summarized by J. F. T. Berliner in a publication of the National Ammonia Co., are as follows:

Chloramine is a much more effective bactericide than chlorine.

It retards or completely prevents aftergrowth formation in treated water.

The chloramine treatment of water eliminates objectionable odors and tastes such as chlorophenol tastes, chlorinous odors and tastes, etc.

It allows a reduction of about 50 per cent or more of the amount of chlorine required for actual sterilization.

The oxidizing action of chlorine is retarded and its absorption prevented, thus allowing practically the total quantity of chlorine to be available for germicidal action.

Chlorine residuals sufficient to overcome sudden increase of bacterial load are feasible when chloramine is employed, both because the taste is controlled and because the solution maintains a sterilizing power for much longer periods than is possible for a chlorine solution.

Berliner states that the only apparent disadvantage of chloramine is that it requires a greater length of time to sterilize the water than with chlorine.

That the ammonia-chlorine treatment will be used extensively seems very probable. There are a number of water supplies not greatly polluted and where the chloro tastes are all the objectionable tastes that are of any consequence. In such waters it is likely that the chloramine treatment will be sufficient. Also there are a number of water supplies where it is desirable to maintain a residual chlorine throughout the distribution system, and to do so with chlorine alone requires the addition of an amount that causes a chlorinous taste. It seems that chloramine should be particularly adapted to such conditions.

There is no doubt that ammonia prevents the formation of chloro tastes such as chlorophenols. There also is evidence that, where any taste is made more pronounced by the addition of chlorine, ammonia will pre-

TABLE I—VALUES FOR $\frac{1}{n}$ AND $\propto$ IN THE FREUNDLICH ADSORPTION EQUATION AS DETERMINED BY KOLTHOFF AND VAN DER GOOT

Material	$\frac{1}{n}$	$\propto$
Phenol	0.15	5.7
Aniline	0.15	6.61
Monomethyl aniline	0.125	6.46
Dimethyl aniline	0.165	8.22
o-Cresol	0.52	19.5
Resorcinol	0.09	3.6
Hydroquinol	0.09	3.8
Catichol	0.07	3.55
Pyrogallol	0.06	3.1
Phloroglucinol	0.06	2.37
Paranitrophenol	0.075	5.05
Gallic acid	0.145	4.0
Pyridine	0.205	5.0
Antipyrine	0.20	3.6
Picric acid	0.46	21.4
Benzoic acid	0.18	11.5
Salicyclic acid	0.12	8.7
Sulfosalicylic acid	0.06	4.7
Benzenesulfonic acid	0.20	2.9

TABLE II—COMPARISON OF PHENOL ADSORPTION WITH LIGNITE BEFORE AND AFTER ACTIVATION

One-gram samples of the materials pulverized to pass a 200-mesh sieve were placed in 1-liter portions of water containing various amounts of phenol and agitated 4 hours; the clear solution was tested for phenol.

Phenol Added, Parts per Billion	Residual Phenol in Parts per Billion: Raw Lignite	Hydrodarco
25	0.0 Tr	0.0
50	4.0	0.0
100	18.4	0.0
300	52.8	0.0
500	154.0	0.0
1,000		0.0
2,500		0.0
3,000		0.0
4,000		0.0
4,500		0.0
5,000		0.7
7,500		12.0
10,000		40.0
12,500		108.0
15,000		223.0

vent the taste being made more pronounced. The writer has met a few who are so enthusiastic over the treatment that they believe tastes of all kinds can be eliminated, even tastes originally present in the water such as algae tastes.

The literature on the ammonia-chlorine treatment is increasing rapidly. Berliner states that for all practical purposes we may consider that the chlorine reacts with the ammonia to form monochloramine (NH_2Cl), and that this probably slowly decomposes into nitrogen and hydrochloric acid. He also states that chloramine is known to have three to six times the bacterial efficiency of chlorine, and that there is no completely satisfactory explanation for this. It is not the purpose of this article to discuss the sterilizing value of chloramine, which appears to be its chief advantage, but to discuss its use in taste elimination or prevention.

Harold[19], Houston[20] and Adams[21] were among the first to note the prevention of certain tastes by means of chloramine. McAmis[22] at Greensville, Tenn., was the first to use ammonia on a plant scale in the United States for taste prevention. Harrison[23] was not very successful in preventing taste at Bay City, Mich., with ammonia. Spaulding[24] reports good success at Springfield, Ill. Braidech[25] states that the value of preammoniation is definitely established as a means of prevention rather than destruction of the phenolic and chlorinous odors and tastes. Tastes and odors are effectively prevented in as high a concentration as 1 p.p.m. of phenol. Cox[26] states that the chlorophenol tastes of raw Lake Erie water at Buffalo were eliminated by preammoniation. Ellms and Ruth presented excellent papers on the use of ammonia with chlorine at the St. Louis convention of the American Water Works association (see WATER WORKS AND SEWERAGE, August, 1930, p. 277). They praised the ammonia treatment very highly for the elimination of tastes. Klein and Brown[27] did not get complete removal of taste at Mamaroneck, N. Y., with ammonia, though there was some reduction. From these favorable accounts of the use of ammonia it is evident that it will be used quite extensively.

The Potassium Permanganate Treatment.—Potassium permanganate is a strong oxidizing compound, and should be effective in eliminating such taste-producing compounds as may be oxidized. The writer knows very little about the treatment, but has heard favorable comments where it has been used. Cox[26] states that "The trial of potassium permanganate treatment at Rochester and Lackawanna, N. Y., was recommended by the New York State Department of Health in the hope that this very flexible treatment would prove efficacious. The satisfactory results secured at these two points leds the department to recommend that similar treatment be utilized at Buffalo, Rensselaer and Waterloo during 1929, when cholorophenol tastes were occurring in these supplies." Cox then states that the treatment was not universally satisfactory, and while it destroyed the chlorophenol taste, slight bitter and astringent tastes were occasionally noted at Buffalo, Waterloo and Rensselaer. About all that may be said in favor of the potassium permanganate treatment is that it is suitable for a few water supplies.

Ozone.—The writer has had no experience with ozone. It is a strong oxidizing compound and should be fairly effective in taste prevention. Certainly chloro tastes are not produced. It has not made much progress in water treatment in the United States, probably due more to the cost than anything else. With a greater demand for more palatable water, ozone may have a limited use in municipal supplies.

The Future of Taste Elimination.—That there is going to be a stampede to try the ammonia-chlorine treatment with the hope that it will at least give partial relief seems evident. Due to the effective sales organizations of the producers of ammonia and manufacturers of machines for handling ammonia, practically every water purification chemist, engineer and water superintendent will soon be informed of the advantages of the ammonia-chlorine treatment. The fact that it can be tried with little expense is greatly in its favor. In plants where it reduces the taste to a satisfactory point its use likely will be continued indefinitely.

The superchlorination treatment followed by dechlorination with sulfur dioxide, or similar compounds, will likely come into fairly extensive use. This will thoroughly establish the advantages of using a strong oxidizing compound. Then the superchlorination treatment followed by dechlorination with activated carbon will gradually become more extensive. Carbon will likely prove to be the cheapest dechlorinating substance, as well as having the advantage of adsorbing tastes not removed by any of the other treatments. It also is particularly adapted to small installations where it is difficult to dechlorinate effectively with another chemical due to the difficulty in applying the dechlorinating compound uniformly in proportion to the residual chlorine present.

Table III is a comparison of several methods of taste elimination or prevention. For some taste-producing compounds such as phenols one has a choice of most any treatment. The chlorine-activated carbon seems to be the only one adapted to most any taste, though the superchlorination treatment alone is not far behind.

TABLE III—COMPARISON OF TASTE ELIMINATION PROCESS

Taste	Superchlorination Followed by Dechlorination with Sulphur Dioxide, etc.	Superchlorination Followed by Dechlorination with Activated Carbon	Ammonia-Chlorine	Potassium Permanganate
Chloro	Eliminated	Eliminated	Prevented	Prevented
Algae	Destroyed	Destroyed	*No change	No information
Fishy	Destroyed	Destroyed	*No change	No information
Chloropheno	Destroyed	Destroyed	Prevented	Destroyed
Oil wastes	No change	Adsorbed	*No change	No information
Decaying vegetation	Largely eliminated	Eliminated	*No change	No information
Earthy	No information	Removed	*No change	No information
Musty	Not removed	Adsorbed	*No change	No information
Humic acid	No information	Removed	*No change	No information
Hydrogen sulphide	Removed	Removed	No information	No information
Aldehol	Partially destroyed	Adsorbed	Probably prevented	No information

* The addition of chlorine usually makes the taste more prouonced, and the increase in taste is prevented by the use of ammonia. There is no evidence that the taste originally present is actually reduced as a result of the addition of ammonia. Most tastes occurring naturally in water are reduced by the filtration process, and this leads some to believe that the ammonia is responsible.

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Hackensack Water Co.'s New Collection Method a Success

The new collection procedure of the Hackensack Water Co. is developing successfully, according to a report by C. J. Alfke, comptroller of the company, to President Nicholas S. Hill, Jr. Statistics compiled by the comptroller's office from 51 cities and towns in Bergen and North Hudson Counties, N. J., indicate that the discontinuance of collectors is proving advantageous both to the public and to the company.

The company aimed to reduce to a minimum the practice of shutting off service, which, experience has shown, in many instances worked injustice to water users. Another aim was to eliminate the irritating relationships which frequently resulted from personal visitation, now regarded as obsolete.

Water bills are now paid either directly to the company or to banks. Delinquent accounts, after ample opportunity for payment has been afforded, are referred to attorneys. Water service is no longer cut off except in rare cases where every other method of inducing a customer to pay has failed.

Twenty-four banks throughout the territory served by the company now act as collection agencies. This method of payment is growing in favor with consumers. In some localities 25 to 50 per cent of the water bills are paid at banks. Illustrating the extent of the detail involved, Comptroller Alfke reported that the company has about 70,000 quarterly accounts which are read and billed daily except Saturdays throughout each quarter under a continuous billing system.

"Our accounts outstanding are no greater in number than they were under our old system, though economic conditions are not as favorable for collections," he said in summarizing results reached during the development period of the new system, which, it is expected, will ultimately both effect economies and establish higher standards of public relations.

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Unusual Design in Welded Pipe Line

An unusual design in welded pipe construction will be employed for a new line for the city of Detroit, Mich., contract for which was awarded recently. This latest contract, the third and largest that they have ever awarded for electric welded Armco ingot iron pipe calls for 2,100 tons or 7,100 ft. of 54 in. and 5,600 ft. of 56 in. pipe. The contract for furnishing and laying this pipe line was awarded to A. Phelps & Son, Detroit, Mich. The pipe will be fabricated by the United Welding Co., Middletown, O.

The pipe will be delivered in 40 ft. lengths for the 54 in., and 30 ft. lengths for the 66 in. The 40 ft. lengths, which are 33 1/3 per cent longer than the standard, will be made of four plates. In 7,000 ft. of 54 in. pipe, this increase of 10 ft. per section, will result in a large reduction of field joints with accompanying economy in field work.

Although welded construction, the pipe will be formed like the old-fashioned riveted page. Plates of pure iron, ½ in. thick and 122 in. wide, either 173¼ in. or 212 in. long, will be rolled so that one plate will go entirely round, forming a complete ring of pipe. Four of these rings (in the case of the 40 ft. section) will be lap-welded in the shop, making a 40 ft. section. This design was first used in the installation of 9,300 ft. of this pipe last May at Detroit and again in November when 9,000 ft. was laid. The circular seams lapped approximately 1½ in., will be welded inside and out, while the longitudinal seams will be butt-welded. In and out courses will be used throughout each section of the pipe. The section will be carefully tested for tightness and the surface thoroughly cleaned and dipped in protective coating before shipment. This combination of the old design and its new application gives a pipe that is unusually stiff, because of the lap-welded circular joints. This it is stated, makes it possible to place the pipe under deep fills without angle reinforcing rings.

Sewage Chlorination for the Protection of Masonry Sewers Against Disintegration

Role of Bacteria in Disintegration of Sewers—Intermittent Chlorination Will Suppress Biological Activity and Prevent Trouble—Experiences in Orange County, Calif., Show Effectiveness of Chlorine as Weapon

By LINN H. ENSLOW*
Associate Editor

NOTWITHSTANDING the generally satisfactory service secured from masonry sewers it is nevertheless true that occasionally such sewers are attacked and disintegrated because of septic sewage. Whenever sewage travels long distances or flows sluggishly through relatively short sewers, bacteria use up the free oxygen and thereafter break down the sulphates present to get the oxygen present in the sulphate radical. When the supply of oxygen is depleted the sewage is considered septic. Such sewage is dark brown, if not black, and hydrogen sulphide gas is frequently liberated when the sulphates are broken down. This gas produces odor nuisances and attacks the masonry and metallic parts of sewers. In normal sewage of domestic origin none of this destructive gas is liberated unless the sulphate content of the spent water supply (sewage) is relatively great. Frequently the high sulphate content can be traced to industrial wastes.

In case hydrogen sulphide should be produced, it is now no longer a problem of a serious nature because this trouble can be corrected by application of chlorine to the sewer. Since the development of this remedy, the selection of construction materials for sewers and manholes can be made without fear of consequences from septization of the sewage. In addition to sewer protection, chlorination of the sewage simultaneously prevents odor nuisance, renders the sewage less infectious and reduces its oxygen demand.

Disintegration of Sewers.—Disintegration of sewers and manholes above the flow line is caused indirectly by living organisms on the surface of the walls. As mentioned above, certain species of bacteria break down the sulphates and utilize the oxygen contained; the resulting hydrogen sulphide leaves the sewage to accumulate in the barrel of the sewer and is thereafter transformed, in part at least, into sulphuric acid. The next step is the attack of calcium and magnesium compounds in the concrete work, in the mortar joints between brick and vitrified materials and in the metal work. Starting with calcium sulphate in the sewage the cycle is completed when sulphates are again produced by the acid attack of the sewer walls and returned to the sewage through leaching action. Later another cycle may be begun further down the sewer and the same sulphur may thereby produce a repeated attack. If the attack progresses sufficiently, the walls or joints are penetrated to an extent which may cause failure of the structure. Such failures have been recorded in connection with brick and mortar construction, and occasionally concrete structures suffer.

To picture the sulphur cycle in sewage the reactions cited below are sufficient for illustration notwithstanding the evidence indicative of intermediate reactions which are not shown. Calcium sulphate is used for illustration, but other sulphates are brown down, also. In these reactions the presence of the essential biological forms, including bacteria, is indicated by the letter "B." The supply of oxygen is taken from the air entering the sewer. It is obvious that if there are no sulphates present in the sewage there will be no "gas attack." It is equally evident that sterile sewage will not cause any trouble.

$$CaSO_4+2H_2O+2CO_2+B=Ca(HCO_3)_2+H_2S \quad (1)$$
$$H_2S+2O_2+B=H_2SO_4 \quad (2)$$
$$H_2SO_4+CaCO_3=CaSO_4+H_2O+CO_2 \quad (3)$$
$$CaSO_4+2H_2O=(CaSO_4:2H_2O) \quad (4)$$

If the reactions stopped with (3) it would be serious enough, but in addition (4) occurs. The sulphate takes on water and crystallizes into gypsum. The phenomenon is in all essentials similar to freezing of water and the wedge effect and swelling produced cause rupture of the structure, spalling of brick, loosening of liner plates or cracking of concrete pipe and segment block. It has been observed that the "putty" produced by the gas attack has a volume two or three times that of the original mortar or concrete. Reactions (1) and (2)

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are the most important and are those caused by bacteria. Without the first there would be no odor nuisance, and without the second there would be no sewer destruction. Since without (1) there would be none of those following, the entire trouble can be stopped by suppressing biological action in the sewage. In cold weather, sewer attack and odor nuisances are not in evidence solely due to subdued biological activity.

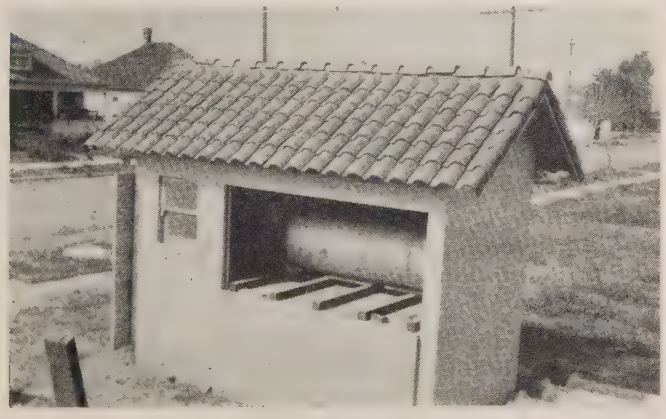
It is obvious that chlorination is required during the hottest periods of the year and can be dispensed with during other periods. For other reasons it is feasible to discontinue the chlorination process during the night when the sewage consists very largely of water and, having smaller volume, does not flow in contact with slime deposits thriving on the side areas of the sewer between the maximum and minimum flow lines. Because of this modified treatment the chlorine required is not sufficient to render the process unduly expensive. The use of the 1-ton chlorine container, as pictured here, has greatly decreased the cost of chlorination of the Orange County sewer in California.

Experiences in Orange County.—Largely because of successful control of odor nuisance by chlorination at the Schenectady, N. Y.; Independence, Kan., and Plainfield, N. J., sewage plants, the California State Department of Health and the Chlorine Institute, carried out some studies on the Orange County sewer in 1928. The results were gratifying and R. F. Goudey in his paper (1) says that chlorine applied in moderation at one or more points along the Orange County sewer "practically stops the sulphate splitting action and in addition to controlling odors, prevents formation of sulphuric acid with its consequent destructive action. By chlorinating at an estimated cost of $3,000 per year, the outfall sewer investment of nearly $1,000,000 can be saved."

Since the completion of these studies, five of the cities contributing sewage to the Orange County outfall sewer have completed permanent chlorinator installations such as are shown here. Inspections at frequent intervals have since shown that the attack on the sewer has practically ceased. Odor nuisance from manholes has been eliminated and beach protection is afforded at the same time.

The practice is to apply chlorine during the hours of maximum sewage flow only; i. e., 9 to 12 hours daily. The quantity of chlorine used is roughly 5 p.p.m. when calculated from the daily flow covering the entire 24 hours; i.e., for each million gallons of sewage delivered to the sewer the contributing town applies 40 to 45 lb. of chlorine. With a chlorine price of 5 ct. per lb. in ton containers delivered by truck this amounts to $2.00 to $2.25 per m. g. of sewage. For large sewers chlorine is available at lower prices in car lots of ton containers; Baltimore, Md., for example, secures chlorine at 2.75 ct. per lb.

The Orange County sewer is an extreme case. The trunk outfall is 26 miles long with branches entering along its course. Many of the branch lines are 5 miles or so in length.



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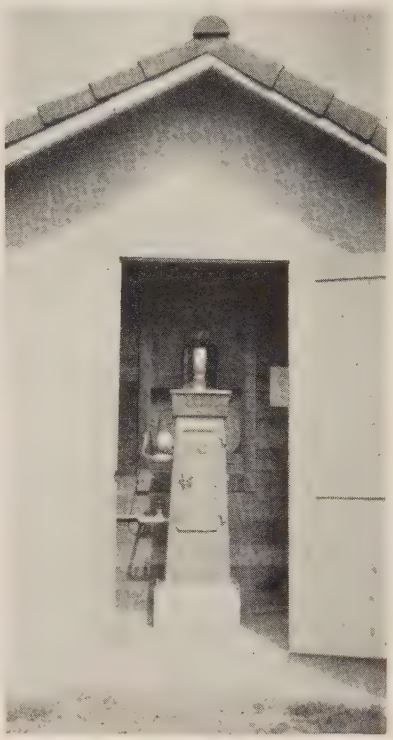

Front View, Fullerton, Calif., Installation, Showing Chlorinator and End of 1-Ton Chlorine Container through Wall Opening

General.—For the reader desiring more complete information a selected list of references is given. The following brief statements may be of interest. The Spirillum desulfuricans is probably the most common organism causing the break-down of sulphates to sulphides. The sulphur-loving bacteria of the Beggiatoa group are largely responsible for the acid production from the sulphides (2). Temperature plays a most important role in hydrogen sulphide production—the range between 77 and 86 deg. F. being optimum for some species of sulphate-splitting bacteria (3, 4, 5, 6). Others function best at temperatures up to 131 deg. F. (7, 8). Certain studies have led to the conclusion that intestinal organisms (B. coli communis) in themselves are responsible for hydrogen sulphide production in sewage and packing plant wastes (6).

Certainly as early as 1897, and probably before this, it was believed that the sulphide gas in sewers was the agent responsible for sewer destruction. This was discussed by the late Rudolf Hering (12) in 1910, and was also carefully noted by Barr and Buchanan (2) in 1912.

Means of lining sewers with acid-resistant materials in the use of protective coatings have been resorted to. As recently as Sept. 1, 1927, *Engineering News-Record* in its editorial columns remarked, "Despite the years of use of concrete in sewers the whole subject of sewer attack is still in so nebulous a stage that all experimentation thereon is well worth while" and further on, "For some years Los Angeles (city) has been lining its sewers with clay tiles and this practice has been

followed more recently at other places. . . . Now at Los Angeles it is found that these liners are none too secure when placed with mortar joints. . . ."

It seems strange that, during the many years intervening between the recognition of the cause of sewer disintegration and the present, the chief weapons used against it were those for combating *effect* alone and that not until 1928 in California was there developed a practicable means of eliminating the *cause*. To this end any means of depressing bacterial activity may be applied; chlorination is merely one means which has proved simple, practical and economical without burdensome initial investment and labor cost.

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Lagooning Sludge

Experience with Sludge Drawn from Digestion Chambers of Imhoff Tanks at Dallas, Tex., Sewage Disposal Plant

By EDGAR WHEDBEE

City Water Department, Dallas, Tex.

THE city of Dallas, with its environs, has a population of approximately 300,000 persons. There are quite a number of industries which produce considerable trade waste, the ones contributing most being a paper mill, two meat-packing concerns and one or two soap factories. While the packing plants are not very large, one, during 1924, killed 107,121 hogs, 5,653 head of cattle, 1,653 calves and 227 sheep; the waste discharged amounted to 200,000 g. p. d., which in strength is equal to approximately 2 m. g. of domestic sewage.

The plant at Dallas consists of 24 Imhoff tanks, designed by James H. Fuertes. Twelve were placed in operation in 1917. Of an additional twelve, six were put in operation in April, 1925, and the other six a little later in the same year. The tanks are about 33 ft. deep, 43 ft. long and 30 ft. wide, with two flow-through compartments and a single gas vent in the center. The sludge beds are about 300x145 ft. in area. During extended rainy spells these beds were filled and the digestion compartments became overloaded; when accompanied by foaming, the tank became a large septic tank.

Slough Utilized as Lagoon.—In the early part of 1926 some experiments were started on the feasibility of chlorinating the effluent in lieu of secondary treatment. At the same time the sludge line to the dry beds was extended down to an old slough, so that excess sludge over the dry-bed capacity could be placed in the slough. Cleaning of flow chambers and gas vents with men and wheelbarrows was started, but this was too slow, so the vertical pipes of the sludge lines were cut off about 3 in. below the ordinary flow line, a removable plunger was placed below the tee in the sludge and the scum was run into the lagoon with very slight trouble. The scheme worked so well that skimming troughs were installed at one end of the flow chamber. At times before any skimming devices were added, the flow chamber would have scum upon it that would analyze as much as 53 per cent of ether-soluble fats and, when dried upon beds, would burn like oil.

Saving Through Lagooning.—The lagoon took care of the skimming and excess sludge, so it looked as though the dry beds could be cut out. Four men composed the dry-bed gang. Labor ran from $12.80 to $16.00 a day—or say an average of $14.00; for 313 days this amounts to $4,382. Pea gravel for the beds required 150 cu. yd. at $2.50 a yd.—a total of $300. Repairs to cars, cost of building track, etc., added another $318, bringing the total saving brought by the lagoon to 5,000. The lagoon was started in 1926, when scum and excess sludge were run into it. Beginning in September, 1927, all sludge and skimmings were run into it. The lagoon is about 5 or 6 acres in extent, and some levee work has been done on the north, east and west sides. No odors have been experienced from the lagoon.

There are two outlets—one at each end. The upper one is an open ditch which follows the contours of the old slough, and from which the clear liquid evaporates during the warm season. On the other end a 3-in. pipe has been placed through the levee. The clear liquid is decanted through a gate valve. During high water in May, 1929, nearly all of the floating scum was washed over the levee. Having dried out by August, it was set on fire, and it burned for several months.

Acknowledgment.—The foregoing is an abstract of a paper presented at the 12th Texas Water Works Short School at Abilene.

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New York Sewage Works Association to Meet at Syracuse

The New York Sewage Works Association will hold a meeting Sept. 13 at the Onondaga Hotel, Syracuse, N. Y. The program includes the following:

9:00 A. M.—Registration
10:00 A. M.—Business Meeting.
10:45 A. M.—Technical Session—Papers and Discussions.
"Use of Chlorine in Connection with Plant Operation"—L. H. Enslow.
"Stream Pollution from the Operator's Standpoint"—Prof. E. B. Phelps.
12:30 P. M.—Recess.
12:45 P. M.—Luncheon, Onondaga Hotel.
Brief Description of Works to be visited.
2:00 P. M.—Inspection Trip to include—
Syracuse Main Sewage Treatment Works.
Sludge Disposal at Lime Waste Beds.
Sludge Digestion and Control at Small Plant, Eastwood.
6:00 P. M.—Return to Hotel.
6:30 P. M.—Dinner at Hotel Onondaga.
7:45 P. M.—Round Table Discussion.
1. "Metal Preservation above and below Sewage Surface"—R. S. Rankin.
2. "Garage Wastes"—John F. Skinner.
3. "Experience with Small Pumping Stations"—Harry W. Eustance.
4. "Pumping of Sewage Sludge"—Irving Nevitt.
10:00 P. M.—Adjournment.

Private Cross-Connections and Similar Menaces to the Quality of Water

Possibilities of Pollution Through Fixtures—Submerged Inlets Classified—Direct Connections to Waste Pipes—Examples of Pollution—Proposed Remedies

By JOEL I. CONNOLLY

Chief, Bureau of Sanitary Engineering, Department of Health, Chicago, Ill.

THE dangers of cross-connections between a drinking-water supply and an impure supply have been recognized for years, and measures have been taken by water-works and public health authorities to guard against them.

The pollution of water by drainage or siphonage from fixtures having submerged inlets and by siphonage from waste pipes is a similar menace to health. The presence of this danger is easily demonstrated in almost all buildings of large size and frequently in smaller ones. The increasing use of fixtures where such pollution is possible has made the correction of the existing conditions necessary, and the longer the matter is put off the more difficult will the task become.

In order to simplify the question before us, let us consider the following items:

1. Every plumbing fixture directly connected to a waste pipe or stack in the plumbing system is a part of that system, and the sewage may back up into the fixture in case a stoppage occurs.

2. Water held in fixtures and traps may be contaminated in the course of their customary use, as well as by backing up of the sewage.

3. If the water inlet to the fixture be submerged in such contaminated water or sewage, the reduction of the water pressure in the inlet pipe to a value lower than the static head will cause, upon opening the inlet valve, a return flow of the fixture contents into the drinking-water supply pipe.

4. Self-closing valves actuated by the water pressure in the supply pipe, such as the common types of flush valves for toilets, become self-opening valves when the positive water pressure becomes changed to a negative pressure or partial vacuum.

5. The partial vacuum in a supply pipe is a common occurrence in many localities, due to (a) excessive use of water at lower elevations, (b) insufficient pumping capacity, (c) heavy draught upon fire hydrants in the vicinity of fire engines, (d) shutting off the supply while making repairs, and to other common occurrences.

6. In large buildings, especially, there is no ready means for the user of a fixture to determine definitely in advance whether a positive pressure or a partial vacuum exists in the supply pipe. The valve is opened and if there is no pressure, one simply waits for water.

Submerged Inlets Classified. — Submerged inlets to fixtures may be classified into two major groups, as follows:

Class 1. Inlets constantly submerged beneath the surface of the fixture contents when the fixture is in normally good operating condition.

Examples of Class 1: Siphon jets in water-closet and urinal traps, steam tables, laundry washing machines, swimming pools, instrument sterilizers, jets in bottom of water-closet bowls used for washing bedpans, bell-supply bath tubs including therapeutic tubs, water baths for many purposes, hydraulic lifts, processing tanks, heating boilers, Bidet fixtures, filters, softeners, stock-watering basis.

Class 2. Inlets not ordinarily submerged beneath the surface of the fixture contents, but which at times become submerged due to carelessness in filling or to stoppage of outlets.

Examples of Class 2: Flushing rim openings in water-closets, urinals and slop sinks; lavatories, bath tubs, utility-room sinks, dishwashing machines, spray heads in air washers, drinking fountains, bed-pan sterilizers.

These examples do not comprise all submerged inlet fixtures but serve to illustrate the differences between the groups.

When fixtures in Class 1 receive human excretions, the greatest precautions should be taken to prevent the entry of the fixture contents into the drinking water.

A flush valve not equipped with a vacuum-breaker device is useless for the purpose of preventing siphonage, because the creation of a partial vacuum in the supply pipe immediately opens the valve. The usefulness of any vacuum breaker upon a flush valve depends, first, upon the valley being closed when the partial vacuum is produced, and, secondly, upon the ability of the device to pass enough air to prevent the formation of a vacuum in the compression chamber of the valve, which, if formed, would open the valve and permit siphonage.

The Menace to Sterile Water Supplies.—For many years surgeons have sought for the cause of post-operative infections. Some factors were discovered and eliminated but still infections continued, sometimes in explosive outbreaks strongly suggesting an undetermined common means of infection. Two years ago Dr. Arnold Kegel, commissioner of health in Chicago, pointed out in an unpublished paper before the Illinois Medical Society that the infection of the water supply by siphonage from a bottom-supply instrument sterilizer, followed by leakage of the germ-laden water into the sterile water tanks through a defective valve, would account for these outbreaks. This was an observation of great importance because wound infections by hemolytic streptococci usually result in the death of the patient.

Direct Connections to Waste Pipes.—An unbroken, or direct, connection from a water-supply pipe to a waste or sewer pipe is not uncommonly found. Very frequently filter or softener drains and wash-water wastes are directly connected to the house drain, in such a position that sewage may back up into the filter or softener during times of storm. Frost-proof closets and cooling coils in ice machines, water stills and water sterilizers are often found to have unbroken connections to waste pipes through which sewage could be siphoned into the water supply. In one instance, ammonia escaping into the cooling coil blew the water back into the street mains, and acting upon the bronze valves, colored

the water blue with copper compounds throughout the neighborhood.

Drains to water stills and water sterilizers also are directly connected to waste pipes, in many instances. This is a pernicious practice, since the condensation of the steam to produce the distilled water, or after sterilizing the water, respectively, produces a partial vacuum which may easily suck sewage into the distilled or sterile water. Such a case has been observed where the attendant thought she was distilling water at an unprecedented rate, but was actually siphoning sewage into the distilled water tank.

Priming connections to sewage pumps are occasionally found. In November, 1927, an epidemic of gastro-intestinal disease among one hundred employees of a large power house in Chicago was traced to a 1-in. connection for priming a pump handling polluted water.

The Remedy.—It is much easier to find improper and dangerous connections in the water-supply pipes than it is to tell just how to remove the danger. Numerous vacuum breakers and check valves have been designed and used. The best way, from the standpoint of entire safety, is to remove all submerged inlets to fixtures and all direct water connections to waste pipes.

If this cannot be done, it may be possible to have every riser open at the top to the air, so that no vacuum could ordinarily be formed in the riser. Where there is a house tank, this can be done by having each riser (except the one supplying water to the house tank, of course) continue full size, uninterruptedly from a point below the shut-off valve, to an elevation above that of the water surface in the house tank, and end in an open return bend to prevent things from dropping into it. As the riser is drained, air will enter the open end and prevent the formation of a vacuum.

Where there is no house tank, the formation of a vacuum in risers may be prevented by proper use of vacuum breakers. In either case the branch leading from the riser to the submerged inlet should be carried up at some point between them to an elevation at least several inches above the rim of the fixture, so that the water will not drain back into the riser because of its own weight.

To eliminate all submerged inlets would mean to rule out flush valves and go back to the use of flush tanks for toilets. There are sound advantages in the use of flush valves, such as economy of space, and not having to wait between flushes, which make one hesitate to adopt so drastic a step. On the other hand, unless precautions are taken in the riser, as mentioned above, some protection at the fixture is essential, as it has been found that with certain types of siphon-jet bowls, it is possible to siphon from the trap of the closet through the jet opening, even while the rim openings are drawing in air.

A good vacuum breaker in the flush valve is of great value, but most, if not all, of those now commercially available leave very little factor of safety for possible leakages past the cup leathers on the plunger, or for failure of the main valve to seat tightly. It is my tentative opinion, based upon unfinished studies, that with fixtures having inlets occasionally submerged (Class 2, as described above) and for use with filtered water, or in places where the creation of a partial vacuum is very improbable, the best of such built-in vacuum breakers in flush valves may prove to be a practicable remedy, provided the valves are properly serviced and kept in condition. For Class 1 inlets, that is, those constantly submerged, and in places where siphonage occurs frequently, some additional protecting device, or a larger air capacity than that of the built-in vacuum breaker in flush valves now on the market, will probably be required for adequate protection.

Certain special types of rubber-faced check valves also may prove, upon further investigation, to give adequate protection to flush-valve connections for occasionally submerged (Class 2) inlets when used with a filtered water supply, or when used in places where the creation of a partial vacuum is very improbable. A combination of check valve and a vacuum breaker of adequate size to prevent a vacuum in case the check valve is held open by débris lodged in it, appears to be the safest available solution of the flush-valve difficulty when such valves are used with constantly submerged (Class 1) inlets and with an unfiltered water supply or in a location where siphoning is frequent. Preliminary tests by the writer indicate that it is possible to have large obstructions in the checkvalve and flush valve, holding them both open simultaneously, and still prevent contamination, by the use of a properly designed and adequately sized vacuum breaker in the water-supply pipe on the fixture side of the check valve. Further tests are now being made to determine the effect of the passage of time upon these devices.

On lavatories and bath tubs the inlets should be placed above the rim of the fixture. Seldom will the overflow openings in such fixtures be found to be large enough to carry off the water as fast as it enters. Where it may be necessary for any reason to have a bell supply, as in a therapeutic tub, special attention should be given to the provision of some adequate device to prevent the formation of a vacuum in the supply pipe, such, for instance, as a combination of check valve and vacuum breaker mentioned above.

Direct water connections to waste pipes should be cut off and the water discharged into a funnel or pipe of larger size, properly trapped. The end of the water pipe should be above the funnel rim.

Conclusions.—To prevent water pollution through submerged inlets to fixtures and direct waste connections, all water-pipe and waste-pipe installations must be more carefully supervised. Manufacturers must join forces with water-works and health authorities to develop safer fixtures or provide protective devices to prevent back pressure and siphonage. All direct water connections to waste pipes should be severed. Whenever possible, submerged inlets should be removed and the water should enter over the rim of the fixture. Where that is not possible the purity of the water supply should be protected by an adequate non-siphoning device.

Acknowledgment.—The foregoing is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

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Central States Section A. W. W. A. to Meet at Youngstown

The annual convention of the Central States section of the American Water Works Association will be held at the Hotel Ohio, Youngstown, Ohio, Sept. 25 and 26, 1930. The program, which is now being arranged, will include papers on water-works accounting, financing of extensions and improvements, water purification and other subjects of interest. A special feature will be an open discussion of practical questions of operation and maintenance of water works and water purification plants. A half-day will be devoted to an inspection of near-by water-works developments.

The Determination of Total Alumina in Filtered Water

Significance in Plant Operation—Necessity for Accurate Control—A New Method for the Determination of Unprecipitated Alum

By F. O. BALDWIN
Superintendent of Filtration, Richmond, Va.

AMONG the many essentials for satisfactory and efficient filter plant operation we have the very important step in water purification of coagulation. This phase continues to command the attention of those in charge and at times baffles even the most experienced. Often the results from coagulation are very poor and adequate explanation of why this is so is difficult—especially if this explanation is to be made to one other than a chemist in the water purification field. Sometimes an imposing array of analytical data accumulated in the laboratory at great labor and expense apparently fails to disclose the secret of poor coagulation. In many cases failure is due to lack of knowledge and to much guessing. This includes the apparent mysteries attached to a rapid change in character of the raw water or else to some subtle influence in plant operation which has been overlooked. There is also such a thing as poor coagulation from lack of proper facilities and due to fundamental errors in plant design.

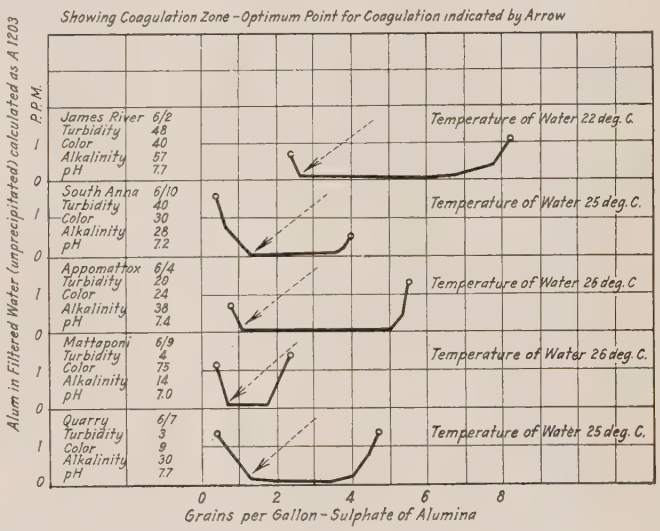
Accurate Control.—Aside from these many reasons for poor results the fact remains that in a considerable percentage of cases there is inaccuracy in dose control methods for alum or other coagulant. This condition of couse usually means surplus expense and a poor quality of filtered water. Too often the dose of alum is the outcome of "rule of thumb" or perhaps is based solely upon "the appearance of the floc."

In an effort to eliminate a very large amount of uncertainty attached to determining the proper dose of alum the enclosed chart has been prepared by means of actual coagulation experiments. This chart represents coagplation results from five sources of raw water as different in character as was possible to obtain within a radius of 40 miles of Richmond. A rapid and accurate means of determining unprecipitated alum made it possible to prepare this chart.

The first thing which we note from the chart is that when the dose of alum is too small, a very large part of the alum fails to precipitate. As we approach the correct or optimum dose, the residual alumina (as the unprecipitated alum will hereafter be designated) becomes less. Finally, when the optimum dose is *struck,* practically no residual alumina is found in the filtrate—usually less than 0.08 p.p.m. At this point analysis shows a very high quality of water, the turbidity having dropped to zero and the color below 2 p.p.m.

Suppose, however, we are dealing with a water which has considerable alkalinity, as the James River shows, for instance, on the chart. Once we *hit on* the optimum dose, it is easy to move along the *nearly horizontal line,* and the degree of surplus alum and therefore *unnecessary* expense can be measured very accurately by the distance back to the optimum dose as indicated by the arrow. Once the optimum dose is reached, any increase in the dose, well within the alkalinity range, does not furnish any improvement in the quality of the water, and the added cost for alum is entirely unnecessary.

Of course there are unusual cases where lack of facilities would make it advisable to add a larger dose of alum than the optimum in order to accelerate floc formation. This would be a case of extra cost for coagulant to compensate for lack of capacity or probably error in plant design. In many filtration plants it is the practice to regulate the dose by such factors as appearance of the floc, the rate

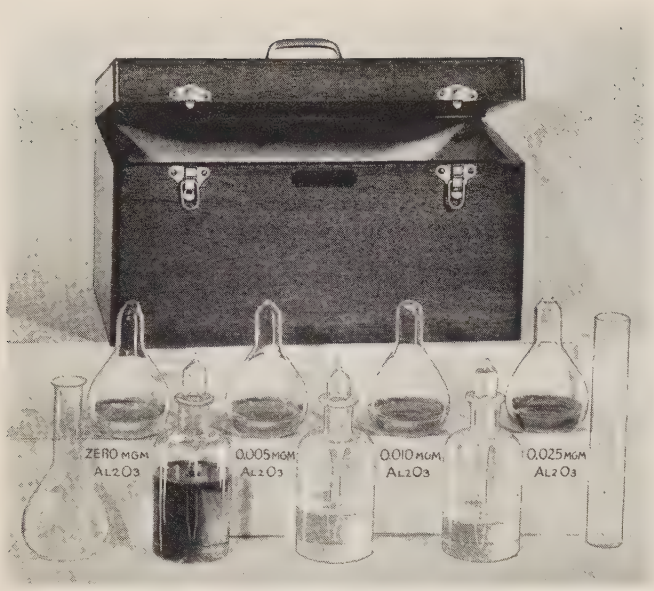


Diagrams Showing Coagulation Zone; Optimum Point for Coagulation Indicated by Arrow

of settling and the appearance of the areas of clear water between the particles of coagulated material, supplemented by filtering through cotton or filter paper and noting the turbidity and color reduction in the filtrate. These observations and tests are excellent, but they fail to show the unprecipitated alum and the degree of surplus dose of alum beyond the optimum point.

Determination of Unprecipitated Alum.—From 1921 to 1924 a method for determining unprecipitated alum in water was developed in the laboratory of the Richmond plant by the writer. This method has been used as a routine determination in both the old and the new Richmond water purification plants for more than seven years and has been a decided asset towards efficiency and economy during this period. The method was published in the December, 1924, issue of the *Journal* of the American Water Works Association under the title, "Total Alumina in Water (Modified Atack's Method) Colorimetric Determination."

The method as originally published was somewhat difficult, but recently it has been rendered very simple (an enormous amount of work was involved). The determination requires less than ten minutes, and its



Alumina Test Apparatus

accuracy has been increased rather than diminished. The number of reagents used is three and a person unskilled in manipulating any sort of apparatus could learn to use the set in a few minutes.

The accompanying cut shows the complete apparatus including reagents, color standards and neat, hardwood mahogany portable carrying case. This case is very important as it protects all apparatus from possible contamination with alum dust.

The principle that alumina possesses an unusual property or faculty of combining with certain dyes is used. F. W. Atack was probably the first to apply this lake formation property to determining minute quantities of alumina in various substances.

The method is sensitive to one part in ten million as Al_2O_3. It furnishes a sort of hairline control of the dose of alum and in our particular case, but for the fact that the James River as a raw water supply is at times extremely difficult to treat, it would probably be possible to hold the dose of alum well within one-tenth of a grain per gallon of the optimum dose. The method in its simplified form is as follows:

Reagents

1. Three-tenths per cent aqueous solution of alizarin red S (alizarin sodium monosulphonate) in 2N sulfuric acid.

2. Saturated solution of sodium bicarbonate. Filter through alumina-free filter paper and add 2 cc. of distilled water per 100 cc. of filtrate. The strength of this soda solution should be held close to a normal solution—that is, 8.4 per cent $NaHCO_3$. Use Arm & Hammer brand of soda—this grade is usually pure enough for most purposes.

3. Fifty per cent acetic acid. This should be made from the highest grade reagent acid and boiled distilled water.

Procedure

To 50 cc. of the freshly collected and well shaken filtered water add 1 cc. No. 1 (0.3 per cent $ARS2NH_2SO_4$). Use phosphoric acid flasks, size 200 cc. Boil 2 minutes on hot plate, neutralize with No. 2 (8.4 per cent $NaHCO_3$) to just barely purple by adding the soda solution very carefully drop by drop and then add exactly 0.5 cc. excess and boil 2 minutes and cool in *cold water*. When cold add 1 cc. of No. 3 (50 per cent acetic acid), let stand 1 minute and compare with color standards sealed in Pyrex 200-cc. flasks similar to the above flask. These color standards are sealed in a partial vacuum, and have to be standardized very accurately.

Acknowledgment.—The foregoing paper was presented at the second annual conference of the Virginia Water and Sewage Works Association at Norfolk, Va.

Sanitation of Roadside Supplies Brings Results

Results of the campaign started in 1923 by the State Health Department of Ohio on that phase of roadside sanitation involving the safety of water supplies used by the traveling public are set forth in the Sept. 1 Ohio Health News.

For purposes of the study, the tier of county general health districts along the Old National Road—U. S. Highway 40—were selected, because the National Road has the largest number of certified water supplies to be found along any Ohio highway, both in actual number and in proportion to its mileage.

Typhoid fever is the chief water-borne disease, and since the general utilization of methods of water purification by municipalities, the larger proportion of typhoid develops in rural districts. With the more general utilization of the automobile for travel, the incidence of rural typhoid was intensified along the main arteries of traffic. For purposes of comparison, the following tables show the typhoid incidence in the selected health districts for the six-year period preceding inauguration of the Seal of Safety campaign and the six-year period immediately following. The tables follow:

Preceding Seal of Safety Work

Gen. Health Dist.	1918	1919	1920	1921	1922	1923	6-yr. Totals
Belmont	39	27	28	51	27	20	192
Guernsey	10	40	12	51	28	15	156
Muskingum	14	7	5	29	19	17	91
Licking	22	19	16	29	14	8	108
Franklin	19	10	23	35	18	11	116
Madison	16	6	8	27	19	14	90
Clark	11	10	12	19	5	6	63
Montgomery	27	21	15	31	17	14	125
Preble	15	12	17	29	4	5	82
Totals	173	152	136	301	151	110	1,023

After Inauguration of Seal of Safety Work

Gen. Health Dist.	1924	1925	1926	1927	1928	1929	6-yr. Totals
Belmont	11	37	40	23	13	11	135
Guernsey	14	22	11	8	3	5	63
Muskingum	6	9	5	7	3	2	32
Licking	5	7	4	6	5	4	31
Franklin	12	11	27	1	12	5	68
Madison	6	3	8	4	0	0	21
Clark	5	5	4	3	10	2	29
Montgomery	13	15	7	4	5	4	48
Preble	3	5	3	5	2	5	23
Totals	75	114	109	61	53	38	450

By comparison with the first six-year period, the second, following the beginning of Seal of Safety work and coincident with its development, shows a reduction of more than 56 per cent in number of typhoid fever cases. It is not to be supposed that all of it is due to improved water supplies along the National Road, because there has been a very general improvement in both municipal and individual farm and homestead sanitation, not only along the highway but also throughout the entire territory. But the benefits of improved roadside sanitation have been so marked that they have resulted in a demand for improved private water supplies and for better sanitation generally, so that the influence of the Seal of Safety has been both specific and general, and a considerable percentage of the decline in typhoid incidence may be fairly credited to it.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor

Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

Trickling Filters

WHILE the idea of the sprinkling or trickling filter was conceived some 40 years ago and while this idea has been developed into one of the most satisfactory and effective oxidation devices known to the art of sewage disposal, there is still very little definite information available on the subject; and there is apparent a wide diversity of opinion on several phases of the subject among workers who have been very intimately connected with the operation of such filters. Aside from the variety of theories expounded to account for the really remarkable results obtained by this device, there is still after 40 years no unanimity of opinion on the matters of ventilation, useful depth, effect of putting temporarily out of operation, etc.

Difference of Opinion.—Noel Chamberlain and I. O. Lacy, of the New Jersey Sewage Experiment Station, have recently made an exhaustive search of the literature on sprinkling filters and have listed some 360 references covering articles from the inception of the idea in 1891 to date, but the sum total of actual information shown to be available is disappointing. The present writer has read and reread the material offered in these references with the idea of presenting somewhat of a digest from which standards could be established, but he finds that apparently equally qualified authorities are at complete variance in such matters as the optimum relation between depth of filter and area, the desirability of rough or smooth filtering material, the depth within the filter at which the maximum oxidation takes place, etc.

The conclusions offered by each investigator seem to be well established by the data afforded in each experiment so far as those data go, and it would seem that the different results secured are due to differences in the influent used on the filters, particularly as regards the condition, or state of disintegration, of the applied influent. In the case of experiments of short duration, the season at which the experiment was made would have a marked effect on what conclusions would be drawn from an attempt to determine either the optimum depth of a filter or the point at which maximum oxidation would take place.

Effect of Preparatory Treatment.—During the years 1913 to 1916 the writer, working with septic tanks and double contact beds, was much impressed with the idea that each of these three steps of the process was merely a preparation for the next step, and that the measure of the success of operation of each step was to be found, not so much in the analysis of its effluent as in the results obtained in the next succeeding step.

There was an intangible something that prepared the onflowing sewage for further treatment, something not to be determined by the routine analysis and which we could not give a name with the facilities then at hand. It is probable that with our advanced technic and advanced knowledge of fundamentals we could now tie this indefinite condition up to pH, nitrogen-carbon ratio and predominating flora, as representing the exact point reached in the progressive disintegration process. If one investigator finds the point of maximum oxidation at the surface of a filter and another finds it near the bottom, it seems logical, from my conception of the progressive nature of the purification process, to assume that the conditions found in each case could be reversed by adding to or taking from the preparatory treatment.

To illustrate this idea crudely, consider an express traveling from New York to Chicago in 20 hours. If a man boards the train at any stopping point he may ride approximately 180 miles in 4 hours but the place he arrives at, at the end of that period of time, will depend on the point at which he boarded the train.

Now the *operator* will normally not be worried about whether a 10-ft. filter is more efficient than a 6-ft. filter. His worry is to make the best of the filter that someone else has provided him with, and this in connection with such other preparatory equipment as may have been provided.

Local Conditions.—If the sewage arrives at the plant in a fresh condition and there is an abundance of settling capacity, the operator could duplicate either the findings of Clarke, who found the greatest oxidation in the upper layers of the trickling filters, or of Rudolfs, who found that the oxidation (nitrification) was greatest in the 2 ft. nearest to the bottom of the bed. The different results would be obtained by using his settling tanks to capacity in one case, feeding to the beds a very thoroughly clarified but somewhat septic sewage, and in the other case by limiting sedimentation so that the sewage would still be fresh and might still contain some of the finer suspended solids.

The factors mentioned above would also affect the findings with regard to the optimum depth of sprinkling filters. In other words, it comes back to the same old question of local conditions. In applying the same influent to beds of various depths the results would depend largely on what stage of disintegration had been reached in the applied sewage at the moment of application.

Local conditions, also, would, of course, determine the desirable stage of disintegration at which the influent might be sent to the filters. My personal inclination is to get the sewage to the filters as fresh as possible and with the least possible sedimentation which will provide against filter clogging. This practice not only assists in keeping down odors at the sprays but passes on to the sprinklers, for aerobic treatment, the finer particles, which can in some instances, at least, be much more easily handled aerobically in the filters than

anaerobically with the sludge. The latter practice results, naturally, in a heavier unloading of the trickling filters and a larger bulk of humus to be disposed of. The "humus," however, is much more amenable to anaerobic digestion than was the material from which it results before treatment of the latter in the filter.

Not only can the operator get the best out of his sprinkling filters by using judgment in the amount of preliminary treatment given, but operators in general can add much to the total of information on the subject by recording and reporting the results of any investigations made to determine the proper degree of preliminary treatment.

Clogging.—Clogging of trickling filters, except in abnormal cases, is more likely to be due to growths on the bed than to the sewage solids themselves. Surface clogging and resultant pooling when caused by such growths is no longer a terror to the operator since chlorine treatment has been shown to be very simple and effective in eliminating these undesirable conditions without in any way interfering with the proper action of the filters. Where means for applying chlorine gas are not available, bleaching powder is found to be equally effective if somewhat more troublesome to handle.

The two objectionable features of trickling filter operation are odors disseminated at the sprays and the sewage sprinkling filter flies which breed in countless millions in the filter film.

Odors.—The former difficulty, odor, can now be effectively controlled by the use of chlorine in quantities just sufficient to oxidize the hydrogen sulphide. Any dosage which gives a slight residual of chlorine will assure the elimination of hydrogen sulphide. With the present low price of chlorine the cost of this treatment to insure against odors is very reasonable. This is particularly true since a study of local conditions will generally reveal that the application of chlorine is necessary only during certain very limited periods of the day. The quantity of chlorine required will vary from 10 to 20 parts per million parts of sewage actually treated. Since such treatment will seldom be required for more than 8 hours daily, the total quantity of chlorine used would be from 28 to 56 lb. for each m. g. of sewage flow. The cost of chlorine varies from 2.6 ct. per lb. for large quantities to 9 ct. for very small quantities.

Freshness of the applied sewage is, of course, an important factor in the amount of chlorine required. For really fresh sewage the requirement approximates zero while for very stale sewage it would run beyond the 20 p.p.m. mentioned above.

Filter Flies.—The other objectionable feature of trickling filters, the filter fly, is extremely difficult to contend with. The only known method of control at present is that of submerging the filter media at regular intervals, usually one week apart. By this means the eggs, larvae and pupae, the three preliminary stages of existence of the fly, are washed out of the filter bed and many of the larvae and pupae are killed by drowning. The full-fledged fly escapes by flying off the bed during submergence and is therefore not disposed of by this treatment.

The adult fly is noticed to be very active at certain early hours of the morning, flying in clouds within a foot or so of the bed surface and collecting on adjacent walls, walks, etc. A great many of these adults can be killed off by spraying such walls and walks with an insecticide, perhaps the cheapest and best of which is plain kerosene. These flies pay not the slightest attention to the ordinary toxic insecticides of either the eating or contact types. We feel that the killing off of such adults as we can reach with the kerosene spray is a valuable adjunct to control of the larvae and pupae by filter submergence, but we know that it is not by any means a substitute for the latter.

We have seriously considered mounting a giant vacuum cleaner on a light truck for the purpose of gathering up the adults during their morning flights, but the fact that only those which are flying free or crawling on dry surfaces could be swept up makes the possibility of actual control rather remote. A far greater number are crawling about in slight cavities on the underside of the surface stones and could not be reached. This latter habit also makes control by treatment of the beds with insecticides out of the question even if we could find an agent which would have any effect on these flies.

Getting the Best Possible Results from the Trickling Filters.—To get the best possible results out of a trickling filter, every part of the surface must be in working order. This means that freedom from pooling and clean nozzles are essential.

Any clogging of the surface will start pooling which will spread rapidly unless promptly eliminated. Mention has already been made of overcoming surface clogging due to growths by the use of chlorine and bleaching powder. Where surface clogging is due to accumulation of sewage solids, the settling tanks are overloaded or worked at too high a rate, or are dirty. That is to say the sludge is not being removed from the settling tanks promptly enough; or, in the case of Imhoff tanks, solids may be returning from the digestion compartment.

The permanent remedy for this condition lies in attention to the settling tank. If the condition has been allowed to get rather bad, recovery of the filters may be somewhat slow after the tank condition has been corrected and may be hastened by turning over and loosening up the clogged areas. If the clogging is general over the entire surface, or over a large portion of it, a horse-drawn garden cultivator has been found very effective in securing the desired results at very little cost.

If one is unfortunate enough to be burdened with a trickling filter in which the material is too fine, or in which fine material has been placed along with standard-size stone, or in which the stone has disintegrated, the harrow or cultivator will be about the only salvation until such time as new filter media can be obtained.

The useful area of the trickling filter is only that portion on which the sewage can be sprayed directly and can trickle away over the surface of the stone. Therefore it will be seen that it is all-important to keep the surface open and in a drainable condition.

It will also be apparent that to make use of the whole bed area it will be necessary to keep the nozzles clean and working properly. It is not sufficient that the sewage reach the bed through the nozzle. It must be sprayed on so as to reach every part of the bed in droplets.

When we stop to consider that a filter influent having a biological oxygen demand of 100 p.p.m. will require 833 lb. of oxygen gas for each m.g. of sewage treated, we begin to realize that nature must be given every assistance in getting this great quantity of oxygen to the sewage during the few minutes that the later remains in the trickling filter.

The writer has found by experiment that sewage dropped, drop by drop a distance of 3 ft. will pick up a dissolved oxygen content of only 3.4 p.p.m. towards satisfying the 100-p.p.m. demand. When the sewage

was dropped on to a stone surface and allowed to film out over the stone surfaces through 3 in. of stone (1 to 1½ in.) the dissolved oxygen content rose to 4.5 p.p.m.

If we calculate the rate of mechanical oxygen solution for the entire depth of a 6-ft. bed we can account for only 36 p.p.m. towards the 100-p.p.m. demand. Chemical and biological forces, of course, come into play to take on and fix the additional oxygen. The point is that the oxygen must be there and the sewage must be presented to contact with this oxygen over the greatest possible area of stone surfaces. The only stone surfaces which are useful are those directly beneath such areas of the bed surface as (1) are free of pooling so as to permit entry of the air and (2) receive a proportionate volume of the sewage in droplet form so that it will film evenly over the stone surfaces.

▼

New Equipment Installed by Water Company at Carlstadt, N. J.

Equipment which in effect constitutes the elements of a complete water works for a small town and which will maintain service at the highest modern standards and anticipate by several years the water needs of three communities in a growing section of the state has been installed at a cost of approximately $50,000 at Carlstadt, N. J., according to Nicholas S. Hill, Jr., president of the Hackensack Water Co.

Two tanks, with a combined capacity of 1,250,000 gal., connected by booster pumps, have been completed by the company to apply added pressure to the 200,000 gal. of water which pass every 24 hours through the Carlstadt station. By means of this accelerating unit, residents of the high points in Carlstadt, Hasbrouck Heights and Woodridge are assured of water service which otherwise, due to natural pressure limitations, would present a difficult engineering problem.

The three communities are supplied by the Hackensack Water Co., from the pumping plant at New Milford. This water is delivered through some 12 miles of pipe lines, and in the vicinity of Carlstadt enters what is known to engineers as a low-pressure area.

To restore the pressure at this point to the standard maintained by the company, the pipe lines have been conducted into a steel tank nearly 335 ft. in circumference, with a depth of 24 ft. and capable of holding 1,000,000 gal.

Rising 100 ft. above this main tank is another steel reservoir tower with a capacity of 250,000 gal. While the large tank fills by pressure from the New Milford plant, two centrifugal pumps raise this incoming flow to the upper tower, from which it is piped into the mains supplying the surrounding district.

To prevent possible inconvenience to the public, all pumping is done at night. The accumulation of water in the tower supplies the normal needs of consumers for 24 hours and allows the use of the large tank for a reserve supply to cover emergencies.

Installation of the new booster unit has been accompanied at Carlstadt by improvements which make radical changes in property held by the company for more than 25 years. A brick tank which was part of the original equipment has been torn down. Grounds have been landscaped and a section of the plant has been equipped as a waiting room for persons using the bus line which passes the plant.

Hackensack Water Co. Completes New Supply Plant

An engineering transformation wrought in a plot of waste land covering less than six acres in North Hackensack and representing an investment of $150,000 has made possible the centralization of the stores and supplies of the Hackensack Water Co., according to an announcement by President Nicholas S. Hill, Jr.

Work begun a year ago last month among stumps, trees and swamp grass west of Hackensack Ave. is nearing completion in the form of one of the most compact and efficient distribution units devised for the use of a modern public utility, in the opinion of construction engineers who have inspected the plant. The plant has been in operation since July 1, and the finishing touches will be completed in another thirty days.

Economies and improved service to the public over a wide area will result from the new plant, Mr. Hill points out. Within the six acres is centralized a distribution system which formerly was administered in six townships, and so complete has been the concentration of plant and equipment in the present site that the company contemplates disposal of three of the old properties and modification of the service at other points.

Buildings of brick, steel and concrete with a total area of approximately 12,000 sq. ft. from the central unit of the plant. Within the main structure are stored stocks of supplies to meet every emergency of construction, repair and maintenance with which the modern water company deals. These supplies are classified in steel-partitioned sections and arranged according to the frequency of demand. "Fast-moving" stock is nearest the exits, where it is most available for handling and loading.

Within each section, along with pipe, water connections, engines, pumps and other equipment are ranged the fittings which are required with each piece of assembly work. Trucks with crews engaged on construction, maintenance, or emergency jobs pull alongside the loading platforms, file their requisitions and are off again in a fraction of the time formerly required to service such orders.

Outside of the plant, in a large asphalt-paved yard extending toward the New Jersey & New York R. R. tracks, are arranged tiers of the heaviest construction materials. A steel crane, capable of handling weights of 2 tons, is used to load trucks with these materials and also to unload freight cars which are run in from the main line of the railroad on a spur track parallel with the Temple Ave. boundary of the plant.

Under the former system, the unloading of a car of heavy machinery and fittings was an all-day job for four men. By means of the crane and the ease of classification made possible by the new "open air" warehouse, the same crew of four now unloads and stores a carload of materials in less than two hours.

The spur track continues beyond the outdoor storage space and runs the entire length of the warehouse. Materials for storage indoors are set off on loading platforms which practically open directly into the sections for which they are destined in the stock tiers. Trucking of every sort is thus eliminated.

An average of $50,000 in stock will be carried in the new yards, and a system of control has been devised which automatically regulates the amounts on hand. A glance at a tally sheet bearing maximum and minimum stock totals enables the supervisor to keep more than a thousand varieties of equipment up to demand without overstocking any line.

Chemical Handling at the Dalecarlia Water Filtration Plant, Washington, D. C.

Pneumatic Equipment Installed for Handling Bauxite, Alum and Hydrated Lime—System Provides Flexibility of Storage Arrangements—Loss of Materials Prevented and Sanitary Conditions Promoted

IN 1927 the Dalecarlia water filtration plant at Washington, D. C., was constructed by the War Department, under the supervision of the district engineer. A study of material-handling methods resulted in the selection of pneumatic conveying for the transportation of chemicals within the plant, and the Dust Recovering & Conveying Co., Cleveland, Ohio., was consulted for recommendations.

The storage building, square in plan, was divided into nine approximately equal squares, providing eight bins around the center space, which was used for an elevator shaft and stairway. In the tower over the bins space was provided for a pneumatic receiving station, from which incoming material could be discharged to any bin through gravity chutes. The Dracco recommendation was accepted, and the operation of the equipment can be followed from the accompanying diagram.

Bauxite, alum and hydrated lime are the bulk chemicals which are conveyed to storage and process by the high-vacuum conveying system. A much larger volume of bauxite is handled than the other chemicals, so the five bins in the two left-hand sections of the storage building are reserved for this material.

The lump bauxite is received by truck, and is dumped into bin, *A*, from which it is fed by gravity to the pulverizer, *B*. The air-separation system carries the pulverized bauxite to the cyclone, *C*, from which the material is conveyed by the high-vacuum system through the pipe line, *D*, to the receiving station, *E*. Discharge either to service bin *H* or to storage bin *I* is provided by the three-gate discharge lock under the receiver, and by the distributor, *F*. From the service bin the bauxite is fed through weigh hoppers to the acid boiling tanks, to produce the required alum.

If it is desired to use bauxite from one of the storage bins, the flexible hose and nozzle, *K*, are connected to the conveying line and dropped into the bin, and the material is conveyed as before to the receiving station, whence it flows by gravity to service. It was originally planned to reclaim material from the storage bins through intake hoppers below each bin, but experience showed a tendency of the material to pack, which made it difficult to maintain a free flow to the hopper. The present arrangement of hose and nozzle is satisfactory and assures free flow from storage bins to service.

To provide an emergency supply of alum, to be used in case of a breakdown in the acid tanks, the center bin in the right-hand section is used for alum storage, with a gravity chute to one of the dry-feed machines, *N*. The lump alum is unloaded, pulverized and conveyed to its storage bin in exactly the same manner as the bauxite.

Hydrated lime is required to neutralize any acid which may be carried over from the settling tanks, so the two remaining bins in the right-hand section are used for this purpose. No pulverizing is required, of course, so the material is dumped from trucks to the platform beside the bin *A*, and is picked up through

Dalecarlia Filtration Plant, Washington, D. C.

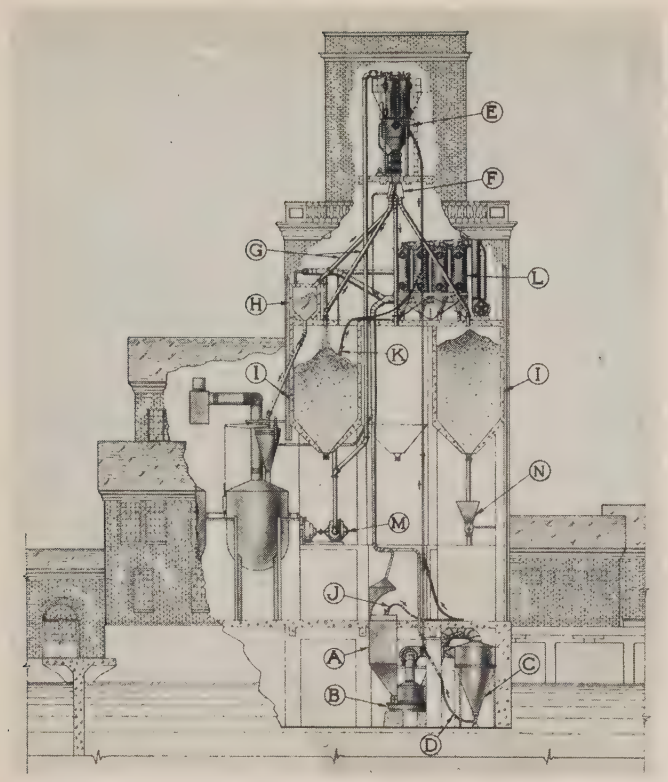


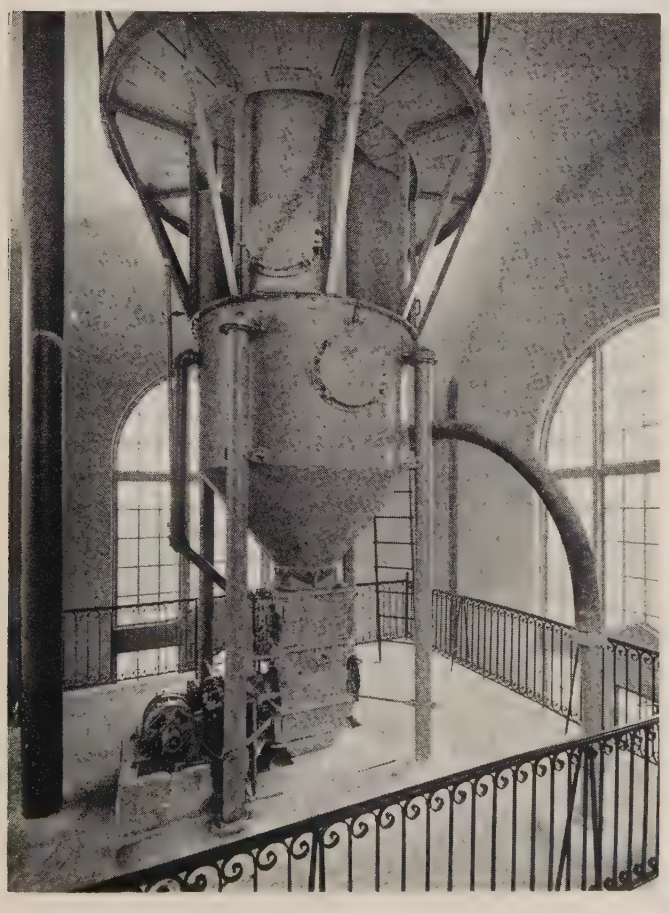
Diagram of Pneumatic Conveying Equipment at Dalecarlia Plant

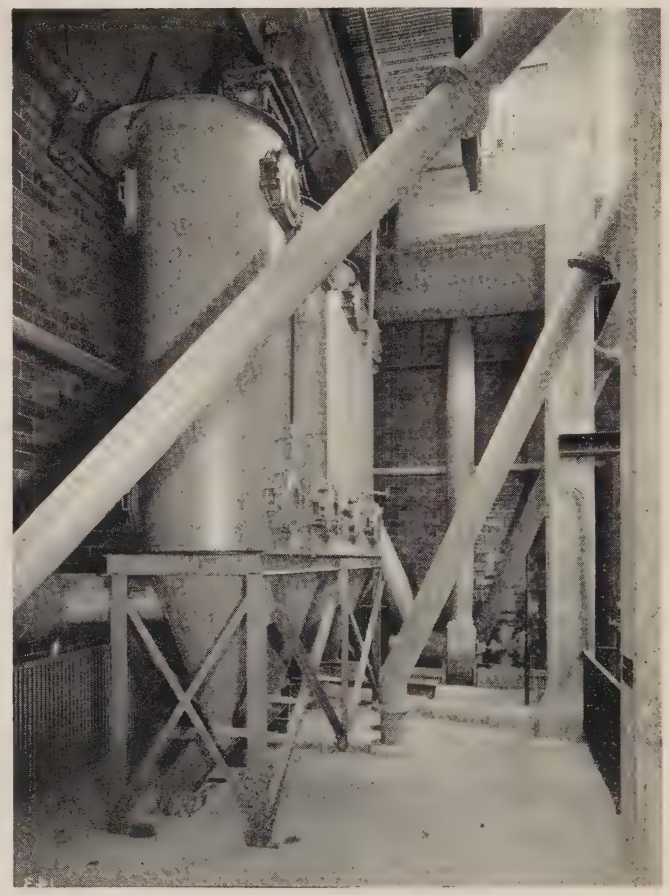
the intake nozzle *J*. A dry-feed machine, *N*, under one of the bins, provides material flow, and stored lime can be reclaimed from the other storage bin through the hose and nozzle, *K*.

The pneumatic conveyor was installed to handle bauxite only, but the flexibility of the system made it comparatively simple to include the conveying of alum and lime, and all three materials are handled in a completely satisfactory manner. The capacity on bauxite is 10 tons per hour, on alum about 8 tons, and a capacity of 5 tons is secured on the hydrated lime. A 50-hp. motor drives the vacuum pump, which maintains a negative pressure in the receiver of 18 to 20 in. of mercury. The discharge-lock mechanism is driven by a 2-hp. motor, giving a total motor horsepower of 52 for the conveying system.

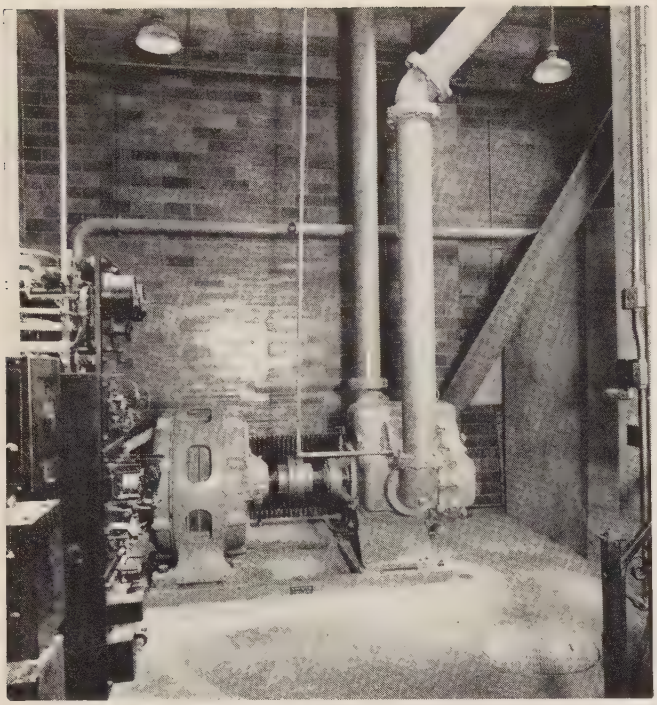
The conveying air, after it has deposited the larger particles of material in the receiver, is exhausted through the three filter compartments which are mounted over the receiver. All the fines are collected on the inside of the filter bags, and discharged automatically by the filter cleaning mechanism, so the exhaust air discharge from the vacuum pump is free from any visible dust. The actual conveying of material is completely dustless, since the piping and receiver are under negative pressure, but there are three sources of dust in connection with the intake and discharge of material. The first is the bin *A* into which the bauxite and alum are dumped; the second, the excess air from the pulverizer cyclone, and the third is the displaced air from the bins which are being filled.

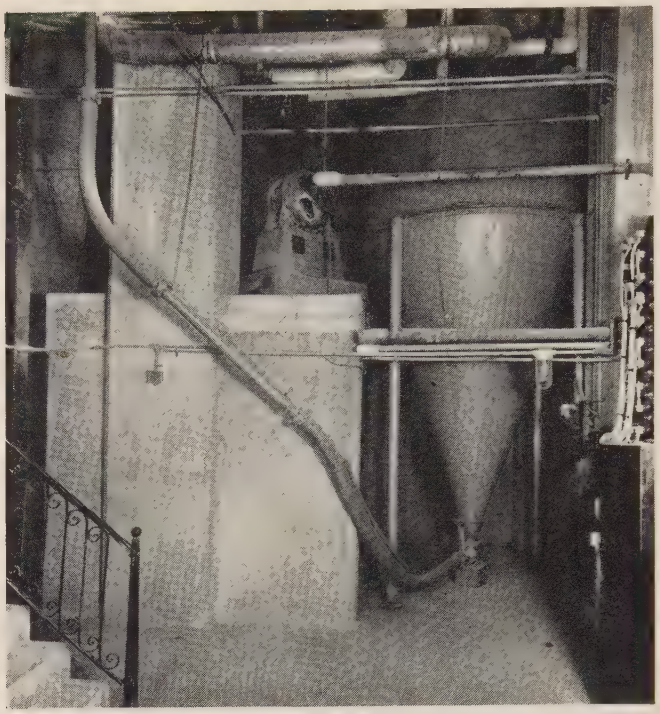
A four-compartment Dracco collector, shown in one of the photographs and at *L* on the diagram, was installed to remove the solids from the dust-laden air which is exhausted from the points of dust origin. A hood over bin *A* provides an inflow of atmospheric air to carry the dust arising from the bin, a connection to the return line from cyclone *C* draws off the excess or vent air and individual connections to each bin provide for removal of displaced air when the bin is being





Left—Collecting Station—"E" on Diagram. Right—Dust Filters—"L" on Diagram





Left—Vacuum Pump—"M" on Diagram; Control Panel at Left. Right—Grinding Cyclone ("C" on Diagram) Showing Intake Hopper Underneath and Conveying Line ("D" on Diagram)

filled. All these lines converge at the filter intake manifold, all visible dust is removed in the self-cleaning bag filters and only clean air is exhausted through the filter fan.

The photographs indicate the neat and sanitary conditions throughout the plant, made possible by the system of pneumatic handling and high-efficiency dust control. The minimum of labor is required, the maintenance cost is low, there is no material loss through dust and spillage and complete flexibility of storage arrangements is assured.

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Observations on Filter-Sand Shrinkage

Results Obtained in Detroit Filter Plant by Increasing Filter Wash Rates—Nature and Origin of Forces That Induce Sand Shrinkage Defined

INTERESTING observations on filter-sand shrinkage were given by W. M. Wallace, superintendent of filtration; Roberts Hulbert, senior chemist, and Douglas Feben, of the Department of Water Supply, Detroit, Mich., in a paper presented at the 50th annual convention of the American Water Works Association at St. Louis. An abstract of the paper follows.

The paper is divided into two parts. Part I discloses the results obtained in the Detroit filter plant by increasing filter wash rates on nine filters, from an average velocity of 29 in. per min. vertical rise (producing a sand expansion of 29.5 per cent with wash water at 50 deg. F.), to the maximum obtainable velocity of 34 in. per min. (producing a 36.4 per cent expansion). This increase of wash intensity was made possible by cleaning of the filter sand with lye solution and subsequent hose scour, which process removed 60 per cent of the coating substance accumulated during five years of service. After restoration of the sand to this extent, it was found that the maximum wash could be applied to the beds without loss of sand. One year's trial of the full-velocity wash indicates that (1) re-coating of the sand is greatly retarded and perhaps is entirely prevented, (2) shrinkage of the sand bed with consequent cracking along the filter walls has been greatly reduced, (3) the formation of mud shelves on the gravel against the filter walls, which greatly aggravates horizontal shrinkage, was prevented during the cold water months and retarded throughout the summer, and (4) maintenance of cleaner sand beds by the higher-expansion wash has increased the average filter run by at least 25 per cent. The writers believe that these observations point to the desirability of using a year-around 50 per cent expansion wash to obtain even better results.

Part II gives the results of horizontal loss-of-head measurements made in filter sands undergoing various degrees of shrinkage. The magnitude of the force which must induce divergence from vertical flow through the sand during filtration is thus measured, and is shown graphically. It was found to vary to a considerable extent in different filters, and in proportion to the final degree of shrinkage exhibited by the bed. This horizontal flow component was also found to be greatly aggravated by mud deposits along the filter walls, resulting in correspondingly greater shrinkage.

Since a horizontal loss of head between different locations at the same depth in the sand bed was observed in a perfectly clean filter, the authors now propose a theory to account for the origin of this force, which must tend to induce shrinkage even in a clean bed of sand—something which heretofore, it was thought, did not occur. Briefly, this new theory is that the unequal voids between neighboring sand grains result in variable velocities and correspondingly different pressures in these spaces during filtration, tending to squeeze the sand grains closer together in the direction of the lesser pressure. The effect of this is to decrease the smaller voids and increase the larger, eventual collapse of the sand into the larger voids; the setting up of a new set of strains, and a continuation of horizontal, as well as vertical compacting of the sand mass.

The Duties and Obligations of a Successful Water Works Operator

Qualifications of Successful Operator—Financial Policy—Public Relations—Accounting for Pumpage—Use of Newspaper Publicity—Application of Rate Schedule—Commercial Relations with Users—Collections—Adjustment of Bills—Handling Complaints

By R. H. COREY

Division Engineer, Public Works Engineering Corp., Salem, Ore.

IT will be found in any study of a successfully operated water works that it is managed with strict regard for the comforts and desires of the consumers and the public it serves. The old-time policy of the railroads of the "public be damned" has given way to the modern idea of the "public be pleased." If the management of the present day water works does not please its consumers, then the public does not hesitate in making its opinion known. No management can long continue that does not make its interests entirely those of the people served.

The Personality of an Organization.—Every organization has a personality that is largely a composite of the individual characteristics of those in authority. What the various individuals do, what they say, how they bear themselves in every detail of life, not only of business and public life but often acts of a private nature, have more weight with the community served because discussion of its policies and acts always exists and thus forms public sentiment. The value of an organization reputation is just as great as is that of an individual. Gossip and rumors about it travel just as far in proportion to its individual members, especially when it is a public service organization.

Every water works organization must have character, individual and corporate, supported by candor and courage to demand that the public be fair with it. There is no question that the public is entitled to full information about all water works problems. The management has an equal right to defend itself and demand fair and impartial treatment when its position is sound.

Naturally every organization serving the public is subject to criticism and it should be if it is fair, honest and constructive. If it is wholesome, the water works should welcome it and not take it as a personal affront. However, if criticism be unjust and unwarranted, the management should stand on their rights if they would have them respected. If the policy has been open and above board, then the critic should be, and can be, held to the same standard with no exception or immunity. Occasionally there may be the yelping of some cheap politician whose self-seeking propaganda can be better ignored, but if there is a shadow of truth it must be openly and frankly considered.

The importance of a good name to a water works organization is more essential to its integrity, to its financial credit and to the maintenance of its ability to meet the demands of public service than any other asset. Good name is equally above all riches in private life, or in the group making up an organization. It is a duty and obligation to maintain it for the benefit of the stockholders, or taxpayers, and the public as a whole.

The Qualifications for Successful Operator.—The water works manager or superintendent should be a man of experience and almost perfect in all human qualities. He should not be simply a good fellow, a politician, or a particular friend or relative of someone in authority, but someone in whom not only the management, but the public will have faith in his ability and confidence in his work. The best possible manager or superintendent will very soon have his hands tied, his organization wrecked and permanent harm done to the system unless those over him give him authority, cooperation and only dictate and decide upon general policies of operation, maintenance, construction and finance.

The water works superintendent or manager stands between the group making up his board of directors or water board and the public served. The required qualifications for a successful operator are those of an almost superhuman being. The ideal water works manager or superintendent should be a man who not only has had good training and thorough experience but who understands the public better than the best politician in his city; who understands business economies and financial matters and has progressive business ideas not only for his own work but for the community as a whole. He must not only understand the character of his public but be an integral part of the city, with the aspirations of the various groups that compose it, and be first among those planning for municipal advancement. He must keep absolutely free from religious and political entanglements and maintain always an absolute neutral attitude in all local controversies—all of these, and more, without ever neglecting or forgetting that it is his duty to provide the best water service possible to the whole community.

The manager or superintendent must be versatile. He must be ready to give the same attention to the feminine consumer's complaint of a meter that causes the plumbing to tick like a clock, as to the pressing problems of more water supply. Keeping up collections, reduction of operating expenses, ability to lead and enthuse men, and the thousand and one problems of the everyday routine, requires sound training, practical experience and financial understanding. Instead of being a spender of money, he must be responsible for the spending. It requires an open mind, free from pet theories, willingness to accept changes and suggestions and always ready to subordinate individual ideas to his superior's general policies.

Taking Advantage of Experience of Others.—It is regretted, but it seems to be true, that the average water works manager or superintendent does not make the experiences of others his own to anywhere near the extent that is done in other lines of work. The operators of nearly every water works system have habits and methods of doing their work that are peculiar to that place and which they are convinced are better than any other. Probably no other industry and certainly no

other public service is so bound up in their own ideas and customs. More progress should be made in management methods. This condition may be due in part to the small salaries paid in many places.

Every water works operator who wishes to get ahead and follow the best practice should not only belong to the American Water Works Association but read every worthwhile water works book and magazine published. Personal experiences in handling the many and varied problems are of great value, but whether it is realized or not the discoveries of others are depended upon more. If the knowledge and methods of others are studied regularly and every possible contact made with other water works men, then the operator will not only profit personally but the work will be done in a better and more economical manner.

Definite Financial Policy Essential.—Good management requires a definite financial policy, whether a privately or municipally owned plant. Available revenue, after operation and interest charges are paid, must be applied to a definite construction program. Extensions must not be laid long distances to anyone who wants service, but a definite policy must be followed. The past history of privately owned water works is full of cases where the systems were stretched out so thin, with few customers per mile of main, that when a major improvement was necessary the finances could not be raised. The result of the consequent poor service was municipal ownership. Then the city owned plants have in too many cases allowed the same thing to happen in that the system is extended into new additions of real estate promoters to the point where general tax funds have to pay part, or all, the interest on water bonds.

Water works sell service. It is very largely a matter of transportation of water that nature has provided at the point of collection. Collection, storage, purification and distribution to the consumer's faucet is only a service, for the water itself is free and costs nothing. The consumer does not wish to emulate Jack and Jill but wants pure water in sufficient volume under satisfactory pressure from every faucet at any moment. Water service should be sold, and the idea that it is the sole stock in trade should be "sold" to the public generally.

The dissatisfaction which arises from poor service is one of the most frequent causes of an unfriendly public attitude. The public will overlook and bear with poor service if the cause is properly explained and steps are being taken to remedy it as quickly as possible.

Good Public Relations Vital.—Experience of public utilities has made it clear that good public relations are vital. It is an intangible asset more valuable than any property. There is a growing tendency to give all that possibly can be in service for the income received, instead of getting all possible for what is received. More cannot be obtained in the future unless a willingness is shown to give to the limit. Then the public will have confidence that the management is giving and will continue to give full value.

Never should one promise, half promise, or even hint, that certain things will be done for consumers or prospective consumers until you know and have investigated all the facts. Then an agreement made must be carried out fully and exactly without evasion or excuses. The matter of a service club should be the guiding principal of every water works organization and every individual in it, that "He profits most who serves best."

The Right to Publicity.—The water works utility should, and does, have the right to place before its consumers and the public the facts in connection with its service and business. It should have the same right to publicity as anyone else and should have the same privilege of correcting false and misleading statements. Its right to protect itself from unjust attack should be conceded by everyone. When publicity is pursued fairly, without misleading propaganda, distortion of facts, no concealment or evasion, then only good can result. It is the duty of the water works management, whether private or municipally owned, to take the public fully into its confidence and be made to understand the nature of the business, the cost of conducting it, the effect of governmental restrictions placed upon it, the part it plays in the life of the community and its needs and necessities. Public relations are then better established and the way paved for a sympathetic attitude on the part of the public.

Good-will is receiving more recognition and attention every day. It is one of the chief assets of a water works. If for no other reason than a purely personal, selfish one, the manager or superintendent will find that it pays. Everything possible should be done to promote and maintain such understanding of common aims and interests that will result in cooperation between the management and the public.

It is the common experience of water works men that the public does not understand modern water works, although generally the people are under the impression that it is a simple matter. More public education is needed and then the cooperation and sympathetic understanding of the consumers will be more easily obtained.

Public Relations Are Influenced.—Public relations are influenced more by the opinion and attitude of the employees than most management realize. In the first place, you can, and must, have organization even where there are only a few employees operating a small system. You must respect the organization yourself by not going over the heads of the office manager or foreman except in emergencies or you will soon lose their confidence and cooperation. Have no time or patience for gossip, tale bearing and jealousy, and insist that those under you observe the same rule, for if you do not you will not only have trouble but not hear the many things you really should know. Gossip among employees has wrecked many organizations completely, and the cashier, stenographer, pump operator, or other employee cannot be allowed to continue creating trouble. Public relations begin and end within the water works organization. Time and study is given to purchase of the best materials and machinery to make up the system but seldom is any care used in the selection of the human element that makes up the organization.

Not only must water works employees be competent, loyal and trustworthy but, due to its being a public utility, all employees must be courteous to each other, their superiors and subordinates and especially so to its consumers and the public generally. No amount of suggestion to, or education of, employees will obtain courtesy unless the employees are treated in the same manner by their superiors.

No organization can project good will toward its consumers and the public if there are constant dissensions and jealousies within itself. Some of these troubles can be corrected and should be remedied as quickly as possible without changes in personnel but when no other solution is possible except discharge then do it immediately. Good feeling within is the most important requisite for creating goodwill without. The attitude of employees is often but the reflected light of their superiors.

There is no place for radicals in religion or politics in a water works organization from its top to bottom. Any employees who show a tendency in that direction should be immediately weeded out, for it not only will affect their work but vastly more important will cause the public to criticise your organization. No matter how efficient an employee may be, the hot-tempered, radical or gossip should go at once.

The outer guards of the water works organization are those who daily see and are seen by, know and are known by the consumers and public. The public forms its opinion of the management very largely from its contact with these employees. Other employees who meet the public less frequently have the responsibility of being their guiding spirit to gain the confidence and goodwill of the public. The personal elements of courtesy, promptness, dependability and efficiency are as fully important as good water service. There never was such a thing as a community fully satisfied, individually and collectively, with its water service. A satisfied public is only one that includes so many who have had courteous treatment, a square deal and the best service possible, that the few others make little stir. Every employee should make constant effort to make the latter class as small as possible.

It should be almost needless to say that the first duty of all of those having to do with management, and especially of the manager or superintendent, is to serve only pure water. At all times not only the person in direct charge but every employee must be on constant guard to maintain the water supply in this condition. There is not only a moral responsibility for the health of the community served but a legal and financial liability should the cause of any illness be traced to the impurity of the water supply. A typhoid fever claim in court does not now have to prove that the polluted water served was drunk and actually caused the disease, but only prove that he was a consumer and the supply at that time it was contaminated. It should be needless to say that your supply should be regularly tested as frequently as possible by a competent bacteriologist. Because nothing has ever happened does not mean that constant tests should not be made.

Chlorination Essential.—There is absolutely no excuse for not chlorinating every public water supply. Certainly no water works manager or superintendent can afford to take a chance in not chlorinating the water supply. No matter whether the supply is from wells or other rarely contaminated source and though frequent bacteriological tests are made of the supply, there should be provided this insurance against typhoid fever and other intestinal diseases. The efficacy of chlorination has been completely proven and more than 3,000 cities use it constantly. There is no question whatever in the minds of anyone of chlorination having any injurious effects on the health, or even producing a so-called "drug store" taste even among people who may be prejudiced against dosing drinking water. European travelers drink the poorly made coffee or tea while over there, or possibly may imbide something stronger, rather than to take the real risk in most foreign cities where chlorination is not generally used. Since the cost of chlorination is rarely more than 2 ct. per capita per annum, this expense cannot be used as an excuse for not providing it.

There is no reason for letting chlorination stop for a single minute. Keep enough reserve supply of cylinders of liquid chlorine ahead of use. If the cholrine apparatus becomes out of order, place a cylinder on a platform scale and run chlorine directly into the supply through a piece of garden hose and gauge the dosage by watching the cylinder weight.

The manager or superintendent should know if the rates charged are equitable between consumers and sufficient as a whole to pay all operating expenses, overhead costs and fixed charges. If the existing rates will not pay operation, taxes, if any, and all interests on bonds with an adequate depreciation reserve, then those in charge and the public generally should be made to know of it as quickly as possible. It is not good business or good politics to serve water at less than its actual total cost.

Management should know if the system will meet all the requirements of the Fire Underwriters' standards for a city of its size and building construction. The Underwriters' reports of the system should be studied and plans made to bring it up to standard as early as possible. Not only is there the health obligation of pure water but also the obligation of providing sufficient volume at all times for fire protection. A large part of the investment in a system is required to furnish a large amount of water for a comparatively short time for fire protection.

Accounting for the Water.—The management should know where its water goes. Water works are purely a means of transportation, that is, a means of no longer requiring many Jacks and Jills to go up the hills. If you fall down in the operation of your system and lose a considerable percentage of your water supply before it is delivered to the consumers' meters, you are not doing your duty. Costs of operation are certain to be out of proportion to income. You may say that you have lots of water and a gravity supply system but sooner or later you will pay for the waste in larger mains, additional supply sources, or other related costs.

First, of course, the consumer waste should be cut down by the use of meters on every connection. This is no longer a matter of argument among those informed in water works economics for water taken in excess of reasonable needs is nothing but waste. Only by use of meters can the consumers be assured of paying an equitable portion of the costs of operation, for the user who allows waste of water, or takes more than reasonable needs under flat rates, robs the careful consumer.

The water system that is fully metered should keep its meters in good, regularly tested condition and the system in such tight condition so that at least 75 per cent of the total supply will be accounted for in delivered consumption. The supply main should have a master meter so your daily total use may be known. A great many cities have been able to beat this percentage of leakage and meter slippage.

No system should be without a recording pressure gauge installed on a separate service connection in the business section. The value of a permanent record of pressures is almost obvious. An extra recording gauge should be available for 24 hours test at various points in low pressure areas which after careful study may help in locating a closed gate valve or aid in planning additional feeder mains. All foremen should have a pressure gauge connected to a separate service in their homes, with an electric bell connected so that it will ring whenever the pressure drops below the normal low point, in order that broken mains may be repaired at once. An electric pipe locator should be part of the equipment and if regular use is made of it there will be saved lots of digging for pipe, as well as the injured feelings of property owners whose lawns would have been disturbed. A pipe pusher should be used for

forcing through small pipe in many difficult locations, saving cutting of pavement and lawns.

Newspaper Publicity Valuable.—Not only may relations with the public be very greatly improved but all consumers will have a very much better understanding of the water works serving them if advertising space is used, and all the newspaper publicity in the news columns that can be obtained. It may not be possible for municipally owned systems to expend money for advertising but if constant contact is maintained with the newspapers they will publish not only items that are news but frequently give space for general articles.

The public must be made to understand that good water supply is the first and most important requisite of life, health and material welfare. Water supply is usually not appreciated and is taken for granted. Water is just water to most people until there is a shortage or its quality changes slightly, then most people know exactly what should be done.

Many water works men may think they are too busy to give time to preparing advertising and publicity. It will help solve most of their problems in public relations and decrease operation problems if newspaper space is obtained regularly. It is true that there are no applicances to promote and nothing but water to sell. It is also true you have a monopoly and no competition. However, if the copy in advertising space is changed often and regularly and the items are short, interesting and free from technical terms and involved descriptions, it will be found surprising how much interest is created and the great benefit that will be derived.

Water works publicity should cover general points about water itself, what it is, its composition, mineral content, that is hardness, its purity, why its quality and taste varies, its value to health, industry and for fire protection. It is not only the cheapest public service but the most valuable. Water at its source is free and rates cover only its collection, purification and transportation to the consumer. There are many very interesting facts about water that can be told that will create a real interest in the local water supply.

Publicity can be given to many worthwhile facts pertaining to better use of the supply by the consumer. Waste of water through leaks and its effect on meter bills can be given. Advice on the better use of water for the irrigation of lawns and gardens should be explained in that thorough irrigation once or twice a week produces better results at less cost than sprinkling every day for a short time.

The consumers can be profitably told many facts about the source of supply, the reservoirs, distribution system, filtration, if any or needed, chlorination, pressures, operation, maintenance, extensions, improvements, meters and water rates.

Very valuable assistance can be obtained in putting over worthwhile and necessary improvements with gradual education through the newspapers that if proposals for them were suddenly brought out might cause opposition and misunderstanding. There are always water works problems that, if the public is taken into consideration, will result in gaining their support. Do not wait until immediate action is necessary to tell your superiors and the public of the vital needs.

There is one point in publicity that must never be overlooked. Always give every newspaper in the territory served the same advertising and identically the same news and publicity at the same time if it is expected to retain all newspapers as friends. The best and most valuable friends any water works manager or superintendent can have are the local newspapers.

There are many more or less minor matters connected with the management of water systems. Maintenance is one of the most important of these items. Maintenance that becomes deferred through neglect or lack of funds is one of the most serious problems because it does not have to be cared for immediately as most maintenance requires. The greater portion of the value of a water works is out of sight underground. Therefore, it would seem good management to maintain all buildings, reservoirs, grounds and equipment in the best possible condition. The slogan of "clean up and paint up" is a good one for water works.

No other business or utility is as lax on the whole in not having proper records and especially complete maps of the water works system. There certainly is every reason for the making of complete maps of existing property and in keeping them up to date. These will be of the greatest value in the future in knowing the location and size of mains, valves and services, and future extensions and improvements can be intelligently planned. In this connection, difficulties with old employees may be saved by having adequate maps as it often happens that old employees, because of their sole knowledge of the system, cause trouble.

Application of Rate Schedule.—The correct application of your rate schedule is a very important matter. It is often surprising to find in a study of the details of the various consumers' accounts that the rates are sometimes not correctly applied. There are often cases where special rates and service charges were given and overlooked. Where there are questions that are not clear in your rates, these should be settled definitely and made a part of your rates and rules. You must hold definitely to your schedules for, if not, you may soon have more or less preferential differences that will be difficult to change or explain. Do not make variations or special rates that are not definitely authorized in your rate schedule. The natural tendency of all of such variations, incorrect applications and special rates are to be less than the correct tariff and reduce your income. A careful examination should be made occasionally of the entire consumer's billing to see that the rate schedule is being properly and fully applied. The manager or superintendent should consult his superiors in all rate variations and questions of any consequence for these affect the pocket book nerve of the consumer. If a privately owned plant, then consult with the Public Service Commission to obtain advice or a ruling in the matter.

Direct Relations with Consumers.—Some of the direct relations with the consumers deserve more study and attention of the management than is often given to them, for they tend to strengthen or break down public relations and confidence if not properly handled. First in importance is the cashier who can and must be the good will representative of the whole organization. The cashier must give the final personal touch of good service that all the other employees work for faithfully. Probably not more than 40 per cent of consumers mail checks in payment of their bills in the average system and the cashier faces the balance every month across the counter. Then there are the new consumers who continually are coming in to arrange for supply. What impression is created of your organization? It can be made good by a uniformly cheerful greeting, tactful, prompt, efficient service and a sincere interest in their requirements. The cashier should be one who will gain and hold the friendship and esteem of all. Next in importance are the meter readers and complaint men who come in daily contact with the public. Only employees of good disposition, neat appearance, consider-

able poise and sound judgment should hold such positions. All must positively understand and remember that they will have to stand occasional abuse without retaliating or losing temper for it is seldom caused by a personal matter, but the water companies policies that cause the outburst that may be due to the irate user who may have gotten out of the proverbial wrong side of the bed. The widely advertised business policy that "the customer is always right" is not true in every instance so a polite, firm, unvarying policy must be enforced.

Commercial Relations with Users Very Important.—A new consumer may immediately become a hidden thorn in the side because of some difficulty that might at the moment be considered of minor consequence. Every possible effort should be made to secure a signed contract before water service begins. This means that your service department must promptly shut off the service connection when a user pays a final bill. Where the owner does not pay the water bills and usually the landlord will not tell the tenant, the new user will have ill feeling enough without allowing him to have service for a time and then forcing on threat of shut off to come to the office to arrange for service. Take a sincere, personal interest in the new consumer. This is the point where your acquaintance begins and the first impression is the most lasting. Please the new customer in the initial dealings and you will rarely have an unjustified complaint from him later. It will not take much time in most cases to know something of the newcomer's plans, hopes or aspirations, without being inquisitive.

The old consumer should never be taken for granted. A cheerful greeting and expressions of personal interest only to the extent that is welcomed and absolutely never beyond that point makes for a kindly regard for the company or department.

Guarantee deposits are absolutely necessary to secure payment of bills and requires a fixed policy with but only rare instances of favoritism. Tenants should always be required to make a deposit and owners who are always in arrears. You should have an equally fixed policy of notifying the consumer and refunding the deposit after a fixed period of say one year of prompt payment. By so doing, you will create a good friend and seldom will such a consumer become poor pay afterwards.

Policy Regarding Collections.—Collections are a highly important matter and there must be a rigid unvarying policy in that respect as any other rule. There are, of course, always consumers who are almost an object of charity. Public water supply is almost the prime necessity of city life and only in such cases should leniency be shown, and then only after someone of your organization has verified the conditions. Then there are occasionally commercial and industrial enterprises that become sick financially, who require careful collection consideration. It is better to have ample guarantee deposits from large consumers in the beginning than to be finally forced to take drastic action. Collections should be definitely and strictly made, according to your rules and regulations, and if not so made, continue service only upon a definite promise of payment on a fixed date. The consumer who is allowed to run bills along without payment for several months will almost always forget the accommodation and invent some service complaint when he is finally forced to pay if he does not move away before without notice. There are many forms of business which are of a personal service nature, such as the railroads, public utilities, fuel and laundry, and which the user has nothing tangible to show for it after it is used and human nature hates to pay for the "dirty shirt" or a "dead horse." Do not hesitate to shut off service on account of delinquent bills and enforce it without fear or favor from the mayor or wealthiest capitalist, down to the most humble citizen, for you will gain more friends than you are certain to lose by being lenient.

Adjustment of Bills.—Adjustments of bills are necessary at times and here again a fixed policy must be maintained and strictly observed without favoritism. Insist on its being done in your office and not at the home or place of business of the user for then you will have all the records available. Large bills, because of allowing faucets to run to prevent plumbing freezing in cold weather and because of plumbing leaks, are probably the most frequent cause of claims for adjustments. Have the meter reader check the meter reading and inspect the plumbing for leaks, then refigure the bill for possible error and notify the user as quickly as possible.

It is hardly necessary to say that there should be no free or partially free consumers. Do not allow any that you suspect of obtaining water without paying to continue without thorough investigation. Even with a 100 per cent metered system there should be a systematic inspection of the users in every city block to check the active consumers and vacancies against the office records to see if there are any unauthorized users. Such inspection should be made without any reference to the office records and only checked after the name, address, meter size and number, off or on, well supply and other necessary data are obtained. It often happens that sufficient additional revenue is obtained to pay inspection costs. Particular attention should be given to lost and abandoned service connections that may have been connected up for unauthorized use.

Meter Reading and Testing.—Meter reading variations, causing high or low bills, must be checked every month. The meter reader should be promptly furnished a list to reread and investigate the cause. All large consumers' consumption and bills should be carefully compared every month before mailing with the month before and the same month of the year before. This will show out of order meters and the seasonal use of water by some industries. You cannot afford to lose a considerable part of the revenue from any large user for a month or many months.

A definite time limit meter testing policy should be adopted. Personally, it is believed that in the great majority of cities the meters are not tested frequently enough. The quality of the water and its effect on meters prevents any general rule for every system for meters measuring some waters might be beneficially tested 2 or 3 times as often as in other places. Certainly residential meters should be tested as often as the results in increased revenue will pay the cost of testing and it might be well argued that it would be good business to test large meters even more frequently than this policy would indicate on account of the difficulty and frequent losses in adjusting large out of order meter bills.

Battery meters are favored by the writer for the large consumers in the average small city where equipment is usually lacking to test meters larger than 2 inch in size. A battery of three two inch meters can be installed at the same cost as a 4 inch meter. Then any one of the meters can be tested at less than one-third the cost of the larger meter without service interruptions, for the small system seldom has spare large meters to install, while the meter is being tesetd. Battery meters save claims of less water use while a large meter is off for testing and repairs and usually give

better total registration because of being tested more frequently.

Handling Consumers' Complaints.—The last point to be discussed, but far from being the least, of good management of direct consumer relations is the necessity of prompt and thorough investigation and settlement of consumers' complaints. It is true that many complaints are trivial or imaginary, but everyone is deserving of full and complete investigation. Chronic kickers are more persistent than algae, B coli, or water dogs and they have no distinction in that they cannot be exterminated but can be very considerably corrected and reduced in number. You should get after them immediately upon their first evidence of life and peacefully and politely effect a cure.

You should have a tactful, discreet man who is well informed to handle all complaints, and use forms that will give both you and the one who enters the complaint full information. No complaint should be considered as closed until you have at least a return postal card from the complainant, stating that the matter has been fully and satisfactorily adjusted. The more important complaints should have the personal attention of the manager or superintendent who should consider it his duty to make complete investigation and correction of the trouble.

The manager of a small system should never remain behind a closed private office door but in sight and hearing of the public counter and ready at all times to take any complaint personally. Do not keep anyone with a complaint waiting but give cordial and complete attention immediately. The customer can then tell his troubles to someone in authority. You must wait patiently until the whole story has been told before you ever offer any suggestion or adjustment for if you do not, it may develop into a hot argument and you have entirely lost a potentially strong friend. Should the complainant not cool down, then promise only an immediate and thorough investigation even if it is a matter that could be satisfactorily explained in a few words. Then write a cordial letter, briefly explaining the situation. You can win good will often from a dissatisfied consumer even though you may not do or concede everything desired, if you are careful to be sympathetic and fully explain all the matters involved in the complaint. If you, or anyone in your employ, are partly or wholly wrong say so immediately and explain why and how it occurred. Courtesy, diplomacy, sympathy and patience are absolutely essential qualities in everyone who handles complaints.

Complaints should be always welcomed and never receive anything approaching a sneer. From an operating standpoint, if not for public relations, the consumers should all feel free to tell of any troubles, for how else will you always know immediately of minor conditions such as occasional stagnant water in some deadend mains.

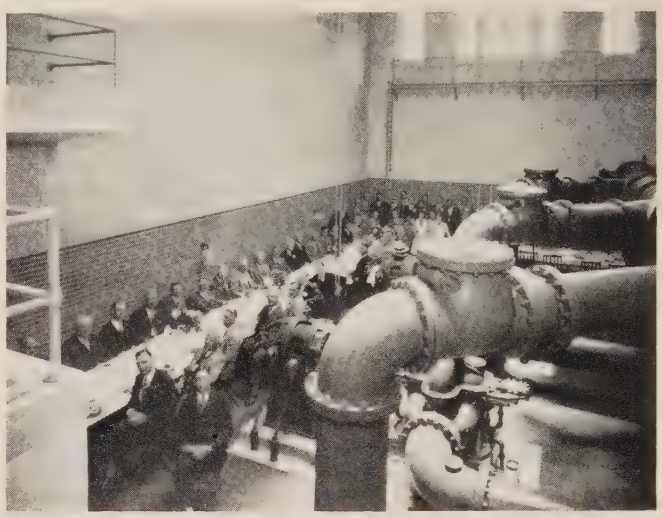
It is a strange fact that the public is predisposed to criticise and be more or less antagonistic toward a public utility whether privately or publicly owned. It is very unfortunate and is a decided handicap that is not encountered to the same extent in private business. This requires that every individual consumer who is dissatisfied, or who has any service trouble, must receive painstaking attention until the complaint is corrected or adjusted on a square deal basis.

Acknowledgment.—The foregoing is an abstract of a paper presented at the Portland convention of the Northwest Section of the American Water Works Association.

Progress in Sewage Works Design

THE accompanying picture, visualizing the progress that has been made in sewage works design, was taken in the pump room immediately adjoining the sewage tanks of the sewage treatment plant of the Aurora Sanitary District, designed by Alvord, Burdick & Howson, Chicago, Ill. The occasion was a luncheon held June 12, the day following the dedication of the plant, during the seventh annual meeting of the Illinois Association of Sanitary Districts, held jointly at Aurora and DeKalb, Ill.

It is interesting, notes Donald H. Maxwell, principal assistant engineer, Alvord, Burdick & Howson, that a portion of the food served at this meal was cooked in



Members of Illinois Association of Sanitary Districts at Luncheon in Pump Room of Aurora, Ill., Sewage Treatment Plant

the plant laboratory with gas from the sewage, generated in the separate sludge digestion tanks. This plant and two others designed by Alvord, Burdick & Howson, generate an average of 0.7 to 0.8 cu. ft. of gas per day per capita of tributary population. The gas generated per ten or fifteen families tributary, is enough to supply the ordinary gas consumption of one family. The gas is used in part to heat the sludge in the separate sludge digestion tanks, thereby promoting the digestion process. The gas averages from 700 to 850 B.t.u. per cu. ft., which is a higher heating value than ordinary gas.

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Sanitary Engineers for U. S. Public Health Service

Examination of candidates for commission as Assistant Sanitary Engineer in the grade of Assistant Surgeon in the Regular Corps of the U. S. Public Health Service will be held at Washington, D. C., and other places if necessary, on Oct. 6, 1930.

Candidates must be 23 years and not over 32 years of age. They must have been graduated in engineering at a reputable technical school or college, and have had three years' professional experience since graduation. They must satisfactorily pass oral, written, and practical tests before a board of commissioned officers, and undergo a thorough physical examination.

Request for information or permission to take this examination should be addressed to the Surgeon General, U. S. Public Health Service, Washington, D. C.

Left—Perforated Pipe Awaiting Installation; Right—Dewatering Excavation

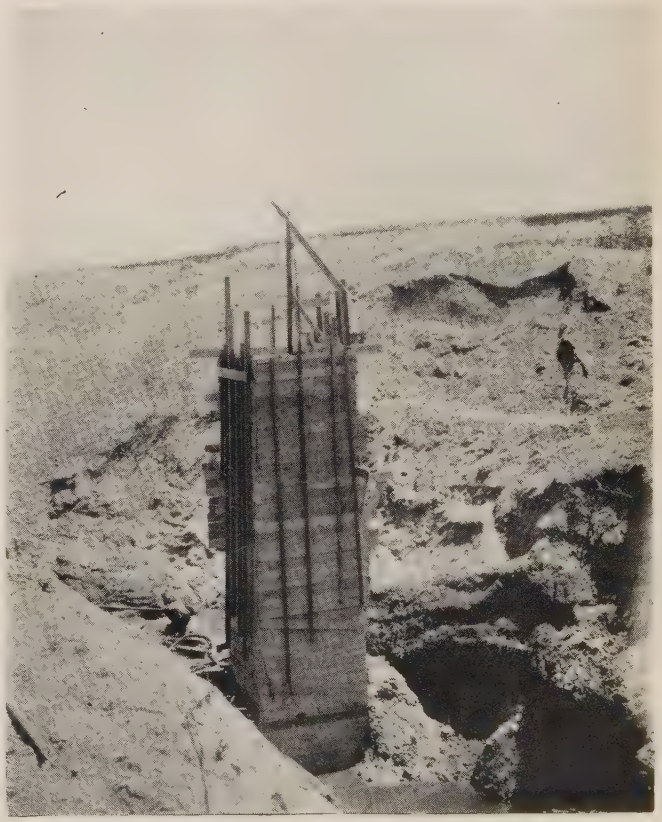
Castle Rock, Col., Builds New Intake

Colorado County Seat Improves Water Works by Extending Infiltration Galleries at Cost of $20,000 —New Intake Placed at Twice Depth of Old Galleries—Corrugated, Perforated Pipe Used

By JOS. C. COYLE

SITUATED at the confluence of Seller's Gulch and East Plum Creek, two streams which are little more than ravines, with a very small flow of water during the dry season, Castle Rock, Col., has long been concerned with the problem of procuring a sufficent supply of water. The town was incorporated in 1881, and a water works system was installed in 1916 at a cost of $65,404 to supply the 500 inhabitants. A concrete storage reservoir, holding 1,000,000 gal., was built on a hill above the town, and wooden infiltration galleries were installed in both the ravines above the town, with 8 and 10-in. wooden pipe leading from the galleries to the reservoir.

Irrigation water rights along the little valley took



Left—Dragline Excavating Trench and Laying Pipe; Right—Manhole Before Backfilling

much of the available water, however, and it was found necessary to extend the intake 2,400 ft. farther up the valley on East Plum Creek this year, placing it at twice the depth of the old galleries. The new installation was completed by Aug. 1, 1930, and cost $20,000.

Excavating, placing the pipe and backfilling were done with a ¾-yd. Marion dragline, the ditch in places being made through a heavy growth of willows, which were removed with the machine. Surface water was by-passed in a temporary ditch. Drainage of the trench was largely by gravity, although a 4-in. centrifugal pump operated by a Fordson tractor was used in dewatering excavations for manholes and a 4-in. diaphragm pump was occasionally used for removing mud by hand. The concrete manholes were installed at angles in the line, and extended 3 ft. below the pipe, acting as sand traps. A little Wonder concrete mixer was employed in pouring the manholes. Hardesty irrigation gates were installed to shut off the flow of water while traps are being cleaned.

Several types of perforated pipe were considered for the intake. That finally decided upon was Armco corrugated culvert pipe. A distance of 1,220 ft. of this is 12-in., 16-gauge pipe, double-riveted and dipped with two coats of hot asphalt. There is 1,210 ft. of similar pipe, also double-riveted and dipped, perforated with ¼-in. holes for 90 deg. of the circumference. This is laid in a single line up through the stream bed, at a depth of 16 to 23 ft. At the upper end a cross-line of 15-in., 16-gauge pipe, treated similarly to that described, and with ¼-in. perforations in 180 deg. of its circumference, will be laid at right angles to the main line, in order to intercept all possible seepage. This line is 400 ft. long, and all perforations are turned up to prevent escape of water once it has entered the pipe.

A strip of clean gravel, 2 ft. wide, was backfilled immediately over the pipe, the first 6 in. on top of the pipe being screened to from ⅜ to ¾ in. in size. This is expected to conduct the slightest flow of surface water to the pipe during the dry months.

Castle Rock is about half way between Denver and Colorado Springs, and is the county seat of Douglass County, one of the first counties organized in the state. It is named for a peculiar rock formation on the top of a small hill near the town. L. C. Tuggle is water commissioner. The Platt-Rogers Construction Co., of Pueblo, were the general contractors on the new installation, and the Wyland Engineering Co. were consulting engineers. John F. Rhoads was resident engineer and C. A. Luce superintendent of construction for the contractors. Pipe was furnished by the R. Hardesty Mfg. Co. of Denver.

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Missouri Water and Sewerage Conference Held Oct. 23-25

The sixth annual meeting of the Missouri Water and Sewerage Conference will be held on Oct. 23, 24 and 25, 1930, at Columbia, Mo. Headquarters will be at the Tiger Hotel.

The aim of the program committee this year is to cover the more important phases of water production and purification as well as sewage disposal. More time is being allotted to distribution, pumping and general problems, in conjunction with the important items of water purification and sewage treatment. At past meetings, men having a national reputation in the waterworks and sewage treatment fields have been present; this year will be no exception.

Erosion May Aid the Engineer, Says New Drainage Bulletin

Drainage engineers need to be able to foretell whether silting or erosion will occur in a drainage channel. Conditions may warrant construction of a ditch of inadequate size with assurance that erosion will enlarge it to the required size. This may effect considerable savings. Before the engineer may safely follow such a course, however, he needs very definite information regarding the probabilities of erosion and silting. Technical Bulletin 184-T entitled "Erosion and Silting of Dredged Drainage Ditches," just issued by the U. S. Department of Agriculture, offers information of this character.

The bulletin gives results of measurements made on 22 drainage ditches of various sizes in Mississippi, Tennessee and Iowa, representing several different soil, topographic and climatic conditions. The changes that took place in these ditches over a period of years were carefully determined by means of numerous measurements of their cross-sections. Observers noted carefully the factors that accounted for these changes.

Among the conditions which influence the erosion and silting of a channel, according to this bulletin, are vegetation, caving and sloughing of banks, backwater, variation in water stages, enlargement of the cross-section, silt charge, variations in fall and the volume of the run-off water. The bulletin discusses the relative importance of these various factors.

To show the practical value of the data, the results were applied to the design of a dredged channel in southern Illinois and it was determined that a saving of $43,650 in the cost of excavation could be effected by allowing erosion to enlarge the channel to the required size.

This bulletin may be obtained free, while the supply lasts, upon application to the Office of Information, U. S. Department of Agriculture, Washington, D. C.

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Accounted for and Unaccounted Water at Dubuque, Ia.

According to the 30th annual report of the Water Department of Dubuque, Ia., of which John W. McEvoy is superintendent, 74.2 per cent of the total pumpage for the year ending March 31, 1930, was accounted for. Of the total pumpage 63.4 per cent was salable and 36.6 brought no revenue. The following table from the report shows the pumpage accounted for:

	Gals.
Salable Water	636,909,750
General Flush of Distribution System	6,500,000
Flushing 2,120 hydrants at 7,500 gallons each	15,900,000
Extension and plumbers' ditches	2,000,000
Service leaks, 136 at 100,000 gallons each	13,600,000
Six hydrants broken (30 min. at 1,000 gallons each)	180,000
Cleaning Level Reservoir (3 times)	1,500,000
Draining West Third Street Reservoir	4,000,000
Known leakage in W. 3rd St. storage reservoir—(24,000 gallons per day)	8,760,000
Meters tested at 35 gallons each	200,000
Eagle Point Station	2,000,000
By-Pass from Low Pressure to Level Reservoir	2,592,000

	Gals.
Flushing city streets and sewers	25,000,000
Two horse fountains and 8 bubblers	8,800,000
Fire Department	8,500,000
City Parks (120 days at 10 hrs.)	3,000,000
Bathing Beach and Athletic Field	1,500,000
Ice Rinks (7)	4,500,000
Free Water Furnished the City	51,300,000
Total Number Accounted for	745,441,750

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A Rain Cycle of 29.56 Days

RAIN cycles of about 2 weeks have been frequently mentioned by meteorologists. Clayton, in "World Weather," attributes that cycle to sun spots; for in the latitudes of most numerous sun spots the sun rotates in about 27.3 days as viewed from the earth, and sun spots are usually most numerous about 180 deg. apart in longitude. This would result in a rain cycle of about 13.7 days. While such cycles can be found, they are not persistent. This lack of persistence led the editor to infer that, while the sun's surface rotates in about 27.3 days in the sun spot region, there is a different rate of rotation below the sun's surface. Investigation disclosed a sun spot cycle of about 29.5 days (*Engineering and Contracting,* February, 1929.)

Following up this clue, a search was made for a rain cycle of about 29.5 days, and Juneau, Alaska, was selected as the first place to investigate.

The daily rainfall at Juneau during the years 1917 to 1929, inclusive, was tabulated by the periodogram method, at first using a period of 29.5 days. This disclosed a rain period slightly longer, and it was found that a period of 29.56 days fitted the facts so well as to leave no doubt as to its substantial accuracy. The periodogram disclosed that this main cycle is divisible into 6 sub-cycles of practically equal length, or nearly 5 days each. These sub-cycles are very marked, not only on the curve of averages covering the entire 13 years, but on curves based on data embracing only 2 years. Of the sub-cycle peaks, those occurring at intervals of about 15 days are most pronounced. A recent rain peak at Juneau was July 14, 1930.

At Los Angeles the rainfall peaks occur about 3.5 months later than at Juneau. This is true, not only as to the average annual maximum, which is early in October in Juneau and in the latter part of January in Los Angeles, but it is true of many individual storm peaks. This "lag" may be attributed to the effect that the 24 deg. difference in latitude produces; for it can be shown that if the axis of an electron-whirl on the sun is in a position to produce a maximum magnetic uplift of an electron-whirl near Juneau, that same solar electron-whirl will produce a maximum uplift of an electron-whirl in the upper air at Los Angeles about 3.5 months later. Intermediate points show less "lag," depending on their latitude.

The existence of rain sub-cycles of $1/6 \times 29.56$ days indicates that the sun has permanent electron-whirls located 60 deg. apart in longitude. In this respect it resembles the earth, for the earth has three permanent barometric "highs," in each of the two tropics, and presumably as many permanent "lows" near the two poles. Photographs of Jupiter show circular spots near its equator, longitudinally spaced about 30 deg., center to center; Jupiter causes a rain cycle that averages $1/12 \times 11.2$ years (11.2 years being the length of the sunspot cycle due to Jupiter), or 11.2 months. An 11-month rain cycle has been noticed by many meteorologists. We find that there are, in fact, two cycles of about 11 months, one of 11.2 months, which is a Jupiter sub-cycle, and one of 10.91 months, which is an Earth cycle.

That there are certain solar longitudes where sun spots tend to originate was shown many years ago by Wolfer, but, misled by the belief that the basic rotation period is about 27.3 days, he failed to find that these sun spot longitudes are permanent. Untermeyer found a sun spot cycle of 29.4 days, but his discovery has been so completely ignored by writers that it did not become known to the editor until after he had found a sun spot cycle of about 29.5 days. A more extended study of sun spots now shows that cycle to be 29.56 days, corresponding with the rain cycle.

While sunspots unquestionably cause rainfall at times, the six permanent electron-whirls on the sun are more productive of rainfall, because they cause rain when there are no sun spots.

Due to the "lag" between rain peaks at Juneau and at places to the south, Alaskan rain peaks can be used to forecast those at points to the south. In 3 out of 4 cases a heavy rain peak at Juneau has been followed by one at Los Angeles 105 ± 3 days later during the past three years.

The Chinaman's Linguistic and Arithmetical Handicap

AS a youngster the writer often watched a Chinese laundryman calculate the bill for the "wash," using for the purpose a "swanpan." This abacus had beads threaded on horizontal wires, along which they could be slid. Lacking knowledge of Arabic numerals, the laundryman had to use this primitive device. Even more primitive were his written symbols, being in fact but a crude development of pictorial writing.

It is difficult for us to appreciate the arithmetical and linguistic handicap under which the Chinese exist. Not only is almost the entire literature of pure and applied science closed to a man who does not understand an alphabet, but even were he possessed of that knowledge still he could make scant progress were he not also acquainted with the system of Arabic numerals. Consider how far you would have progressed in scientific knowledge were you able to compute only by the aid of an abacus.

Even as the average Chinaman is now mathematically handicapped, so were almost all Europeans handicapped until about 450 years ago. The first printed arithmetic appeared in Italy in 1478, the first in Germany in 1482, the first in England in 1522, the first in America in 1719.

It is true that the Arabs had learned the basic features of their numerical system from the Hindus about the year 800, and that Arabic arithmetic became known in Christian Europe about 400 years later; but no wide-

spread knowledge of this system occurred until the printing press was invented.

The use of the zero, which gives place value and is therefore the most important part of the so-called Arabic system, is first found in an Indian land grant of 738 A. D. Some unknown Hindu genius had finally hit upon a place system advancing by multiples of 10; and by that single change had revolutionized the whole art of computation.

The next great step was the introduction of decimal fractions, which was in 1585 by Simon Stevinus, the Dutch genius who discovered the hydrostatic paradox that the downward pressure of a liquid is independent of the shape of the vessel and depends only on the area of the base and the height of the liquid. He conceived the idea that the tides are due to the moon.

To a Scotchman, John Napier, the world is indebted for the next great invention in the art of computing numerically, namely logarithms. In 1614 he published his remarkable work containing the first logarithmic tables by which multiplication became merely a process of addition. That book has been regarded by many as second only to Newton's "Principia." Perhaps the most remarkable feature about this great mathematical invention is the fact that Napier deliberately set out to simplify multiplication and division at a time when algebra had not yet advanced to the point where multiplication was performed by adding exponents. By the aid of arithmatic and geometry, and with no aid from algebra, Napier accomplished his purpose. Slide-rules are mechanical substitutes for printed logarithms.

The vast majority of Chinamen still remain ignorant of alphabetical writing and Arabic computation. Need we wonder at their racial backwardness, in spite of great natural intelligence? Continually they writhe under the tortures of poverty, periodically they starve by the millions, and blame their sufferings upon everything but their own ignorance.

Engineers Lack the "Centered Mind"

IT is hopeless to argue with a strongly prejudiced man. It is foolish to quarrel with one. We shall neither argue nor quarrel with the writer in *The New Republic,* who says: "There is an obvious lack of centered minds in our civilization today; and there is nothing in the tradition of the engineer that will bring them into existence. But until such minds come into being our civilization may be easily ruined by its colossal powers, and victimized by the machine's benefits." This is the closing explosion of an explosive person, in a review of "Toward Civilization," written as a symposium by certain well known engineers.

With some small measure of pride the authors of "Toward Civilization" point toward the achievements of engineering. With a great measure of sarcasm the reviewer says that engineers "combine the chivalry of a Bayard with the intellectual resourcefulness of a Faraday," and admit the combination. Then, casting aside the rapier of sarcasm for the bludgeon of invective, the reviewer says, "If he (the engineer) is as powerful as he asserts, he must take his share of the responsibility for the raucous defects of current industrial society, but if he is just a hired mercenary, he should not boast too loudly of his mastership. . . . They take comfort for our present failure by their charming ignorance of the past; and they bid us look hopefully toward a future which they give us no genuine ground for welcoming; since, unless a quite different order of intelligence comes into existence from that which they complacently exhibit, the future will too closely resemble what is behind."

This last sentence leads us to suspect that its writer is himself not conversant with at least some part of past history; such, for example, as that the British annual average wages remained practically stationary in buying power between the years 1300 and 1800, and then increased four-fold in the first century of the existence of engineering as a recognized profession. We do not imply that this great increase in real wages in Europe, and the even greater increase in America, is to be attributed entirely to engineers, but we do insist that pure science combined with applied science, impelled by the urge for personal profit, fully accounts for this startling emergence from the thralldom of hand-to-mouth existence that had previously been the common lot.

"One wants, first of all, to know if the engineer realizes what his origins are. Is there any notion among these distinguished contributors, that their art has as its social foundation the destructive occupations of mining and warfare?" asks the reviewer, and answers promptly, "None whatever." It so happens that he is accidentally right in this answer, for there is not the slightest historical evidence that engineering originated either in the mines or on the fields of battle. You can find such statements in some encyclopedias, where doubtless the reviewer learned what he thinks he knows about engineering. But suppose it were true that engineering began as a military art, what of it? Suppose iron was first made for use in spears and arrows, does its initial use affect its present value to mankind? If we may revile the man of today because of what some ancestor did, how many of us would escape contumely?

Speaking of the origin of things, almost every treatise on the science of probability says that its first laws were discovered in an effort to assist gamblers to bet more judiciously. Astronomers tell us that astronomy had its origin in that form of quackery called astrology. If so, these add but two to the many examples of the evolution of admirable things from germs that were not admirable.

Our reviewer, as above quoted, speaks of the "centered mind," and although he got that expression from Emerson, we think a better one might have been used; for just when and how is a mind "centered"? Said Emerson: "In a centered mind, it signifies nothing how many mechanical inventions you exhibit." Since Emerson evidently used the word "centered" in a peculiar sense, we must infer his meaning. He means a mind of the sort that sees no great merit in railways, motor cars, airplanes, typewriters, telephones, moving and talking pictures, harvesters, rock crushers, concrete mixers, pumps, sewing machines, vacuum cleaners, dynamos and motors. And it is but a step from this inference to the conclusion that a "centered mind" lacks admiration of all the discoveries in pure science that preceded and made possible these mechanical devices.

Our reviewer charges engineers with lacking the "centered" type of mind. It is as if he had charged a bird with lacking fins. From such centering of intellect as he admires we certainly are free. Life for us does not approach sublimity through idle speculation or ceaseless talk, but through creative action. To us it seems great to be able to understand the greatness of nature and to rival her mechanism even though our understanding be but partial and our rivalry but feeble.

H. P. Gillette

Convention of New England W. W. Association

THE annual convention of the New England Water Works Association will be held at Atlantic City, N. J., September 23, 24, 25 and 26. Convention sessions will be held at the Haddon Hall Hotel. The program, as announced by E. Sherman Chase, chairman of the Program Committee, follows:

TUESDAY, SEPT. 23

Forenoon—Registration, opening addresses, etc.

2:00- 2:45 p. m.—Committee reports.

2:45- 3:15 p. m.—"Disinfection of the Wanaque Aqueduct" by Attmore E. Griffin, analyst, North Jersey Water Supply Commission.

3:15- 3:45 p. m.—"Recent Developments in Chlorination" by Francis D. West, manager of sales, Paradon Manufacturing Co., Arlington, N. J.

3:45- 4:30 p. m.—"The Flow of Water through Corroded Service Pipes" by Gordon M. Fair, professor of sanitary engineering, Harvard University, Cambridge, Mass.

4:30- 5:00 p. m.—"How Small Cast-Iron Pipe Is Made and Used" by J. R. McWane, president, McWane Cast Iron Pipe Co., Birmingham, Ala.

9:00 p. m.—Reception and dance at Haddon Hall Hotel.

WEDNESDAY, SEPT. 24

Special train leaving Pennsylvania Station, Atlantic City, arriving at Florence, N. J., at 10:30; leaving Florence at noon, arriving at Burlington approximately 12:15; luncheon at Burlington, followed by inspection of U. S. Cast Iron Pipe and Foundry plant; leaving Burlington about 3:00 p. m., arriving Atlantic City 4:30.

Afternoon—Ladies' card party at Haddon Hall.

THURSDAY, SEPT. 25

9:00- 9:30 a. m.—"The Atlantic City Water Works" by Lincoln Van Gilder, engineer and superintendent, Atlantic City.

9:30-10:00 a. m.—"Copper and Health" by William G. Schneider, of the Research Department of the Copper and Brass Research Association, New York, N. Y.

10:00-10:30 a. m.—"Modern Aspects of Color Removal" by A. S. Behrman, chemical director; R. H. Kean, research chemical engineer; and H. Gustafson, chemist, International Filter Co., Chicago, Ill.

10:30-11:00 a. m.—"A New Development in Wrought-Iron Pipe Manufacture" by Dr. James Aston, consulting Metallurgist, A. M. Byers Co., Pittsburgh, Pa.

11:00-11:30 a. m.—"The Submarine Pipe Line between Portland, Me., and Great Diamond Island" by Harry U. Fuller, chief engineer, Portland Water District, Portland, Me.

11:30-12:00 noon—"The Story of Anaconda," a moving picture dealing with the production of copper pipe from mine to consumer.

2:00- 2:30 p. m.—"The General Water Supply Situation of Northern New Jersey" by Morris R. Sherrerd, chief engineer, State Water Policy Commission, Newark, N. J.

2:30- 3:45 p. m.—"The New Wanaque Water Supply" by Arthur H. Pratt, consulting engineer, Newark, N. J.

3:45- 4:15 p. m.—"Methods Attempted for Prevention of Phenol and Other Tastes in Water Supply at Rahway, N. J.," by Mortimer M. Gibbons, water-works chemist, Rahway, N. J.

9:30 p. m.—Smoker at Haddon Hall.

FRIDAY, SEPT. 26

Business meeting.

Exhibits.—A feature of the convention will be the exhibits of manufacturers. The list of exhibitors includes the following:

Paradon Mfg. Co.
National Tube Co.
Neptune Meter Co.
The American City
R. D. Wood & Co.
Union Water Meter Co.
Hersey Mfg. Co.
Bingham & Taylor Corp.
Leadite Co.
Simplex Valve & Meter Co.
United States Pipe & Foundry Co.
Ross Valve Mfg. Co., Inc.
Hydraulic Development Corp.
A. P. Smith Mfg. Co.
American Brass Co.
McWane Cast Iron Pipe Co.
Lock Joint Pipe Co.
George A. Caldwell Co.
Pittsburgh Equitable Meter Co.
Chicago Bridge & Iron Works
Lead Lined Iron Pipe Co.
Atlas Mineral Products Co.
Rensselaer Valve Co.
Public Works
Wallace & Tiernan Co., Inc.
Water Works Engineering
Central Foundry Co.
Cement Lined Pipe Co.
Gamon Meter Co.
Worthington Pump & Machinery Corp.
Phoenix Meter Corp.
Pardee Engineering Co.
Gillette Publishing Co., publishers of WATER WORKS AND SEWERAGE
Engineering News-Record
Pittsburgh-Des Moines Steel Co.
Kennedy Valve Mfg. Co.
Pitometer Co.
Builders Iron Foundry
Eddy Valve Co.
Badger Meter Mfg. Co.
Warren Foundry & Pipe Co.
National Meter Co.
Red Hed Mfg. Co.
Vogt Brothers Mfg. Co.
Ford Meter Box Co.
Norwood Engineering Co.

Haddon Hall Hotel, Headquarters of N. E. W. W. A. Convention

New Equipment and Materials

Timken-Equipped Wintroath Deep-Well Pump

Wintroath Pumps, Ltd., of Alhambra, Calif., has recently announced a new line of anti-friction bearing-equipped deep-well turbine pumps that have several interesting points. The line includes pumps of capacities ranging from 25 to 6,000 g.p.m. and the ratings range from 3 to 400 hp. The standard pumps are directly driven by an electric motor, but they may be modified for belt drive by gasoline or oil engines. The line is especially suitable for work on irrigation systems, municipal water-supply systems, industrial water supply, or domestic systems such as farms, private estates, and similar cases. They can be used on either shallow wells, or those exceeding 500 ft. in depth, where the internal diameter of the well is 6 in. or over. In addition to lifting they may be used as boosters against any desired pressure above ground.

The construction is quite simple, the pump consisting of two main parts, the head, and the impeller mechanism, or pump proper. The former consists of a cast-rotor squirrel-cage vertical-type induction motor, which is connected to the impeller mechanism by a sectionalized line shaft. The motor is designed for across-the-line starting, so that the control consists simply of a start-and-stop push-button station that can be located at any convenient point. The weight of the motor rotor, shaft and impellors is carried by a Timken thrust bearing mounted on the lower end of the rotor shaft. Another anti-friction bearing is used as a guide bearing at the upper end of the shaft. One of the interesting features of the head is the lubrication system that has been adopted. There is an oil bath or reservoir surrounding the Timken thrust bearing, and located so that it extends downward into the discharge chamber of the head. Thus the oil is kept at constant temperature by the cooling action of the discharged water. Oil from this reservoir is pumped to the upper, or guide bearing, whence it flows back to the reservoir. This continual circulation of cool oil not only prevents any possibility of overheating, but greatly lengthens the effective life of the lubricant.

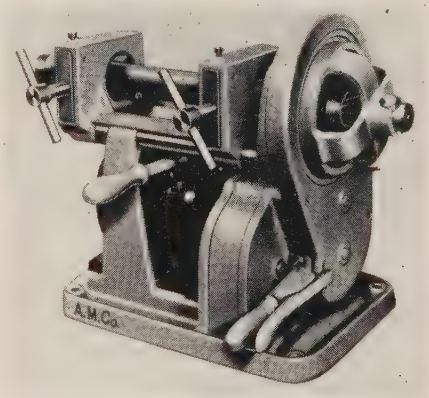
The head is connected to the pump by a line shaft consisting of 10 or 20-ft. sections of Cumberland turned and ground shafting coupled together. It is carried in phospher-bronze line-shaft bearings spaced about 6 ft. apart. This construction makes it a simple matter to lower the pump to follow a retreating water level. The pump proper is of the multi-stage centrifugal type, totally enclosed. The impeller is both hydraulically and dynamically balanced, and extra long bearings have been provided. The intermediate castings, which make up the stages, are equipped with replaceable bronze bushings at the point where the impeller shaft passes through them. The pump is provided with a suction strainer consisting of galvanized half-round wire wound flat side out around a conical steel framework. The construction is such that gravel or similar foreign matter cannot lodge in the openings. Suction pipe can be furnished in any desired lengths.

Wintroath Deep-Well Turbine Pump Directly Driven by Electric Motor

▼

New Pipe-Threading Machine

A new pipe-threading machine, designed for a wide range of uses, has been developed by the Axelson Mfg. Co., Ltd., Los Angeles, Calif. Its operation is simple and the machine occupies a minimum of space, according to the manufacturers. The pipe that is to be threaded remains stationary while the standard square die is revolved, cutting the thread. This differs from many other types that require revolving of the pipe. Long stands of assembled pipe or bent pipe may be conveniently threaded as it is unnecessary to rotate the units. The work is gripped by two jaw chucks which are practically automatic and instantaneous in action. Standard square dies, obtainable from practically any supply house, are readily adapted to the cutter thread. Threads can be cut on material from ½ to 2 in. in diameter and the power is supplied from a ½-hp. compound-wound motor, installed directly beneath the pipe-holder brackets. Electric current of 110 or 120 volts, either 50 or 60-cycle, may be applied.

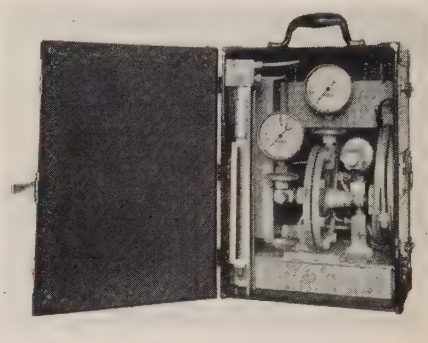


New Axelson Pipe-Threading Machine

The manufacturer claims that the threader will cut at the rate of 17 r.p.m. on all sizes from ½ to 2 in., and the required time for completing 11 threads is about 40 seconds. After the thread is completed the dies are reversed, and during this operation rotate at 34 r.p.m. Attachments are available for the cutter head to permit cutting off, reaming and bolt making.

A New Portable Ammoniator

The Paradon Mfg. Co., of Arlington, N. J., has recently developed a portable ammoniator. The apparatus consists of a standard Paradon Type ADB ammoniator, housed in a fiber carrying case and resembling a piece of hand luggage. The portable ammoniator is adapted to continuous regular use as well as emergency use, as it is designed to do anything that any ammonia-control apparatus will do.



Paradon Portable Ammoniator

In design, it is essentially like the familiar type of Paradon chlorinator except that the parts are made of material that will withstand the corrosive effects of ammonia. A shut-off valve is provided to keep moisture and foreign material out of the apparatus during periods of non-use. No water supply is necessary for its operation, the ammonia gas being applied directly.

The apparatus can be supplied for any range of capacity from 1 to 300 lb. of ammonia per 24 hours. Equipment can also be supplied that would decrease the minimum capacity to 0.05 lb. of ammonia per 24 hours.

The use of ammonia in connection with chlorination of water supplies is spreading rapidly. Many of the applications of ammonia are temporary and seasonal. It was for taking care of this type of ammonia application that the Paradon type ammoniator was developed.

▼

New Sealing Compound

The Quigley Co., Inc., New York, N. Y., manufacturers of Hytempite and Triple-A protective coatings, announce the manufacture of a plastic, expansive compound for sealing joints, called Q-Seal.

A micaceous mineral having expansive properties is ground to a very fine mesh and used as the principal pigment in the compounding of Q-Seal. The principal vehicle or mixing agent used is one that is impervious to crude oils, all of their derivatives, acids, etc., and is non-corrosive.

Q-Seal is easily applied to joints to be sealed with a brush. The expansive qualities fill any imperfections in threads, flanges or gaskets. The compound seals joints leakproof, and prevents rust and corrosion.

WATER & WORKS SEWERAGE

OCTOBER, 1930
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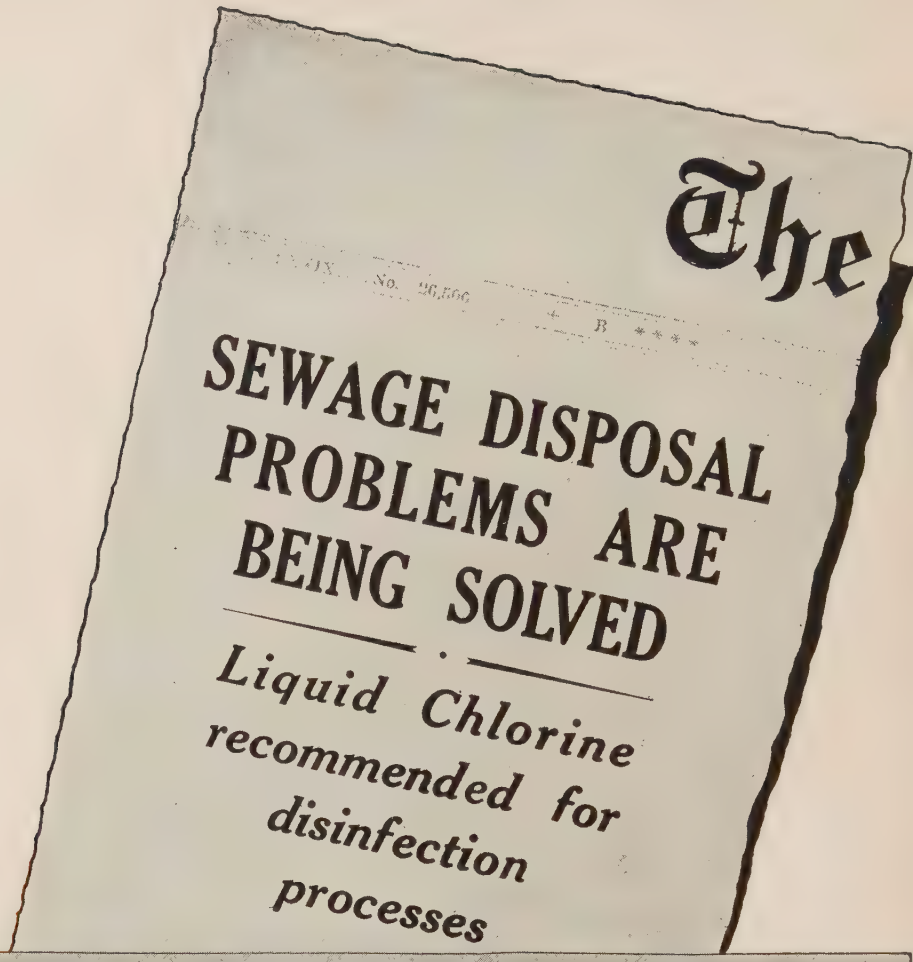
MEMBER A.B.C.—A.B.P.

onstruction View on Sept. 4th, of Old Mill Stream Dam of Additional Water upply of Wilmington, Del. S. N. Van rump, Chief Engineer Water Commis oners; W. Compton Wills, Deputy hief Engineer; Fuller & McClintock Consulting Engineers.



Liquid Chlorine

Progress registered in the treatment of sewage is due to the intelligent zeal typical of modern scientific research. The installation of efficient sewage treatment plants has naturally followed.

Actual plant operations have conclusively proven that Liquid Chlorine is an effective aid.

The facts about this helpful chemical are interesting and valuable. E B G has published a booklet "Liquid Chlorine in Sanitation," which every engineer, city authority and others interested in the subject should read. Copies will be gladly forwarded, upon request.

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Water Works and Sewerage

H. P. GILLETTE, Editor

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Tower and Chute for Placing the Pipe

Laying a 8,500 Feet Submarine Pipe Line

Methods and Costs of Constructing a Main in Casco Bay from Portland, Me., for Furnishing a Water Supply to Fort McKinley on Great Diamond Island

By HARRY U. FULLER

Chief Engineer, Portland Water District, Portland, Me.

THE work consisted in laying a 12 in. main 1,700 ft. long between the mainland and Mackworth Island and an 8 in. main 6,800 ft. long between Mackworth Island and Great Diamond Island.

The contour of the bottom crossed the mouth of a river with a depth of 30 ft. and for about a mile varied between 15 and 25 ft. in depth. The material is blue clay overlaid with from 1 to 2 ft. of silt. Soundings were made over the entire length of the line with a 40 ft. piece of 1 in. pipe. There was no difficulty in churning this sounding rod 6 ft. into the underlying clay.

The pipe was purchased by the Portland Water District from the U. S. Pipe & Foundry Co. and delivered to the contractor on a convenient wharf.

The Bids.—Bids were received on April 29, 1929. They were as follows:

	Bay State Dredging and Contracting Co.		Merritt Chapman and Scott		Bennett Contracting Corp.	
Quantities	Unit	Total	Unit	Total	Unit	Total
1,700 ft. 12 in.	$10.28	$17,476	$11.00	$18,700	$13.50	$22,950
6,800 ft. 8 in.	9.20	62,560	8.60	58,480	7.65	52,020
Total		$80,036		$77,180		$74,970

The contract was let to the lowest bidder. He had previously laid a 16 in. submarine line in Portland Harbor and had done other submarine work, thereby demonstrating his ability.

Construction Equipment.—The contractor provided a lighter 28 ft. x 80 ft. having an 80 ft. boom for handling the pipe and pipe chute; a lighter 20 ft. x 54 ft. rigged with a derrick for excavating and back filling and a pile driver 24 ft. x 54 ft. The lighter used for excavating was provided with outrider pontoons to give greater stability.

On a previous similar job this contractor had laid the pipe by means of curved chute suspended between two lighters.

On this job, he made a change in the method of holding the chute. He built a tower of timbers properly trussed which rested on the bottom of the bay and extended above high water. Attached to this tower was the curved chute used for laying the pipe.

The legs of the tower were fastened to skids which formed the feet of the structure. In general appearance, this apparatus suggested a giraffe with his four legs standing well apart.

This tower spanned the trench which had been pre-

The Lighter for Excavating Had Outrider Pontoons

viously dredged. The lower end of the chute extended downward into the trench, and served to smooth off any irregularities left by the bucket in dredging.

The pipe laying chute was about 90 ft. long and of such curvature that the pipe did not exceed a defection of 10 degrees. The upper end of the chute was tangent to the curve to allow the joints to be made up straight. The lower end of the chute was so curved as to allow the pipe to slide off into the trench without straining the joints.

Platforms for workmen, making joints, were provided near the top of the "giraffe."

The "giraffe" was a complete success in every respect. There was no movement due to wave action and during rough weather it was not necessary to lower the pipe and pick it up later with the accompanying undersirable movement of the joints. The contractor has applied for a patent on this apparatus.

The dredge preceded the pipe layer by only a short distance, digging a trench 5 ft. deep and about 10 ft. wide on the top and perhaps 5 ft. wide on the bottom.

The dredging was done with an orange peel bucket. The material was deposited on the bottom at one side of the trench and later handled back into the trench.

The large lighter was kept beside the pipe laying chute and placed the successive sections of pipe in position for jointing. It also moved the giraffe by lifting the front end and dragging it ahead as each section of pipe was laid.

Laying the Pipe.—The approaches to the submarine line having been laid by ordinary land methods to a half-tide point, and the dredge having completed something over 100 ft. of trenching at high tide, the "giraffe" was set in position about 50 ft. outside of the land end of the pipe.

It was found that some time could be saved by jointing two pieces of pipe on the deck of the lighter and hoisting the two pieces as a unit to the pipe laying chute. This was made possible by the presence of the large and powerful lighter with an 80 ft. boom. Furthermore, the lighter by this method could move the giraffe 24 ft. at each movement.

Two pieces of pipe were placed in the chute and the lead joints poured and calked. The pipe after sliding down the chute was then scooted ashore.

This operation is related to the use of a cableway with the whip from the boom forming the cable and the pipe hanging from a snatch block riding on the whip. By this method the end of the pipe was carried toward shore as successive pieces of pipe were joined in the chute until the end of the submarine pipe was 6 ft. from the land pipe. This opening was left to allow a plug to be leaded in the end of the submarine line for testing purposes.

It was also helpful to allow the entire line to be laid

The "Giraffe" in 20 Ft. of Water

and back-filled in order that any settlement that took place could occur before the ends were completed.

From this point, the pipe laying consisted of adding successive lengths to the line in the chute and pulling the giraffe along.

Time Required.—The work was started on June 10 and completed September 18, making 100 days of elapsed time and averaging 85 feet of pipe daily.

Laying the 12 in. pipe required 17 working days in 31 elapsed days with an average of 100 ft. daily for working days and 60 ft. daily for elapsed days. The best day's work was 168 ft.

Laying the 8 in. pipe required 30 working days and 41 days of elapsed time with an average of 222 ft. daily for working days and 162 ft. daily for elapsed days. The best day's work was 408 ft.

Testing.—The specifications required that the leakage in the line should not exceed 4 gal. per linear foot of pipe joint per 24 hours at 150 lb. pressure. For the 12 in. line this worked out to be 1.67 gal. per minute.

The first test was made on Saturday and showed 1.83 gal. per minute. Monday morning a second test showed 1.33 gal. per minute and on Tuesday the leakage was 1.19 gal. per minute.

This progressive tightening of the line confirmed previous experience.

For the 8 in. line, the allowable leakage worked out to be 4.6 gal. per minute. The test was made in the afternoon and showed a leakage of 1 gal. per minute. A second test an hour later showed no leakage. The hand pump used in testing held the pressure gage at about 150 lb. with no movement.

A gate was then closed between the pump and the line and the gage read 152 lb. It was left in this condition at the end of the day's work and on arrival the next morning on the job, it was found that the gage read 105 lb. Thus, it appeared that the line was bottle tight, a somewhat remarkable showing for a watermain of this type.

Cost.—On the 12 in. line 170 ft. of foundation cost $3,263, or $19.00 per linear foot.

The 377 ft. of 12 in. pipe laid by land methods on the flats between high water and mean-tide cost $2,473 or $6.60 per linear foot.

The 1,820 ft. of 12 in. submarine line exclusive of foundation cost $35,050, or about $19.00 per linear foot.

The following tabular statement shows the details of the above figures.

Cost of 12 In. Submarine Line

	1,820 Ft. 12 In. Sub. Line	377 Ft. 12 In. Line on Flats	170 Ft. Pipe and Cap Foundation	2,197 Ft. Total
Cost of pipe	$ 7,252	$1,097	.....	$ 8,349
Labor and rent of equipment	24,476	1,208	$1,560	27,244
Other materials and supplies	1,659	72	1,559	3,290
Engineering and overhead	1,663	96	144	1,903
Total	$35,050	$2,473	$3,263	$40,786
Cost per foot	$19.25	$6.57	$19.20	$18.50

The 8 in. line cost $68,705 or $10.30 per linear foot. The details of cost are shown in the following table.

Cost of 6,660 Ft. of 8 In. Submarine Pipe

Feet		Cost	Per Foot
5,832	New flexible joint pipe	$12,830	$2.20
828	Old flexible joint pipe	1,429	1.72
6,660	Total pipe	$14,259	$2.14

Cost of 6,660 Ft. of 8 In. Submarine Main

	Cost	Per Foot
Cost of pipe	$14,259	$2.14
Labor and rent of equipment	51,465	7.70
Other materials and supplies	451	.07
Engineering and overhead	2,530	.39
Total	$68,705	$10.30

Raymond F. Bennett, President of the Bennett Contracting Corporation, had personal charge of the execution of this work. Roy H. Beattie was consulting engineer, and Eben L. Parrott was inspector of construction. The writer was engineer for the Portland Water District.

Acknowledgment.—The foregoing is an abstract of a paper presented Sept. 25 at the 49th annual convention of the New England Water Works Association.

▼

Installing a Flexible Joint Pipe River Crossing

An important feature of the distribution system of Buffalo, N. Y., is the flexible joint cast iron pipe under river crossings in navigable streams. There are three of these, all of 16-in. diameter pipes. The first was laid across the City Ship Canal at Harbor Turnpike in 1918 and is 240 ft. long. The other two were laid across the City Ship Canal and Buffalo River at South Michigan Ave., and are respectively 250 ft. and 404 ft. long from shore connection to connection. The method of assembling and installing these mains was described by Wm. H. Grotz, Assistant Engineer, Division of Water, in a paper presented before the New York Section of the American Water Works Association. The note following is taken from his paper.

The pipes were class "B" with the Metropolitan type ball and socket joint, in which the lead remains in the bell when the joint is deflected. A trench across the river bottom was excavated by dredge to a depth of 37 ft. below mean low water level between harbor lines, with the shore ends rising on an easy curved slope. The pipes were put together in sections on a flat scow, and as each joint was poured and caulked, it was deflected and another pipe added. Those sections which were to lie in the bottom of the river were made up of pipes 12 ft. long, while those to be used at the shore ends were 6-ft. lengths, this to provide greater curvature. The last pipe at each end was fitted at the top end with a standard bell for connection with land pipes.

Flat scows were lashed end to end the entire width of the river and the pipes transferred to these by a derrick scow. The entire length was thus made up and suspended to the sides of the scows by rope lashings. Rope lines were then attached to alternate pipes and fastened about snubbing posts, and when ready to lower, these lines were slacked off slowly about the snubbing posts, permitting the pipe to settle slowly to the bottom, the center portion of the main being allowed to settle first. When the main rested on the bottom, the ends above water were capped and an air test of 120 lbs. applied. A diver followed up the joints during the test, caulking any joint found to be leaking. The shore ends were then connected in the usual manner, and a 5-ft. fill of good earth was then deposited over the pipe trench in the river bed for protection. These lines are in service constantly and have given no trouble since laid, and are about the tightest mains in the system.

Visitors, Citizens, Admire Glassboro Sewage Plant

VELVETY lawns, beds of flowers of brilliant hue, a wooded background and an attractive access road distract the attention of the casual visitor at the Glassboro, N. J., sewage treatment plant from its more import function in the community. The accompanying illustrations convey some of the impressions such a visitor might carry away.

The plant, which was put in service in 1926, is situated in a dense wood on the banks of the Chestnut Run branch of Big Timer Creek, about 1½ miles northwest of the center of the borough and about ¼ mile from the nearest road. It consists of an Imhoff tank, open sludge-drying beds, a sprinkling filter with a siphon dosing tank, a chlorinating chamber and a final settling tank.

The plant is reached by a hard-rolled cinder road, kept free from grass and weeds. Signs notify visitors that they are welcome. Smooth trimmed lawns surround the plant units, which are connected by concrete walks and steps. Cannas, zinnias and marigolds are grown in the flower beds, and groups of dahlias, rose bushes and evergreens have been carefully placed to set off the various units most advantageously. The influent pipe, which is elevated about 2 ft. above the ground, is hidden from view by rambling roses. The near-by wood has been cleared of underbrush, and marshy spots have been drained and filled in. Close attention is given to the tank and filter to prevent any trouble that would detract from the pleasant impression given by the plant.

The Glassboro plant was designed by Remington, Vosbury & Goff, of Camden, N. J., with William Goff in complete charge of the installation. Operation of the plant is under the supervision of C. H. Shute, superintendent of sewage disposal.

Large stones painted white mark the road leading to the Glassboro, N. J., sewage disposal plant

Left—The influent pipe is partly covered with flowers

Below—View of plant, showing chlorine house, final settling basins, filter bed, dosing tank, Imhoff tank, sludge-drying beds and garage

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Filtration Engineer, Bureau of Engineering, Chicago, Ill.

Bacterial Aftergrowths in Water Distribution Systems

A NUMBER of water works have at times been troubled with bacterial increases in the water after it leaves the purification works. Sometimes the increase has been so great as to create doubt as to the safety of the water. Health officials have in some instances become very much concerned about the conditions of the water and have insisted on the chlorine being increased, frequently to the point where it gives the water a disagreeable chlorine taste. Even this has not altogether prevented the aftergrowths. It is the desire of every water works official to furnish water that is safe for human consumption at all times, and at the same time he wants to furnish water that is palatable. It is the purpose of this article to give some information on the causes of bacterial aftergrowths and to suggest remedies.

During 1929 the Committee on Water Supply of the Public Health Engineering Section of the American Public Health Association collected data from a number of cities throughout the United States on bacterial aftergrowths in water distribution systems. The report of this committee was published in the May, 1930, issue of the *American Journal of Public Health.* The worst conditions as found by the committee were in cities either not filtering their water, or in cities having open reservoirs connected with the distribution system beyond the point where the water is treated. The writer has been able to collect some additional data on the subject that might be of value.

Why Progress Has Been Slow.—Probably the main reason why little progress has been made in preventing bacterial aftergrowths is that the cause has not been determined in most instances. In fact in most instances those who are aware of such troubles have made little effort to prevent the aftergrowths, though there are a few who have increased the chlorine dosage over what is necessary to make the water test safely shortly after the application of the chlorine, hoping to lessen the aftergrowths. The writer will give his experience with aftergrowths, hoping it will stimulate others to study their conditions and to apply remedies.

While operating a small filtration plant in 1915 and 1916, bacteriological samples were collected weekly at several points on the distribution system of the city remote from the filtration plant. The sampling points were on what are commonly called "dead ends." In most instances the samples did not show results greatly different from those at the filtration plant. There were times, however, when both the counts and the B. coli were considerably higher than at the plant. The writer collected the samples—the procedure being to open a fire hydrant, let the water run for about one minute at a rate of perhaps 15 to 20 gal. per minute, collect the sample, and then flush the "dead end" by opening the hydrant wide for 5 to 10 minutes. The flushing kept the "dead ends" in fairly good condition, except for an occasional increase in the bacteria.

Experiences at Baltimore, Md.—The writer's next experience with bacterial aftergrowths in a water distribution system was at Baltimore. Samples were collected daily for several years from the laboratory tap at the filtration plant. This was water that had passed through several miles of the distribution system before returning to the filtration plant through the distribution mains. After leaving the filtration plant the water flowed first through a tunnel, and then large pipes to a pumping station about 2 miles away, where part of it was pumped into the section of the city where the filtration plant was located. The hydraulic grade line to the pumping station was considerably above the ground line, so there could be no possibility of ground water pollution. At that time the pumps did not run continuously. While they were running the excess water over the consumption went into a balancing reservoir of about 37 million gallons capacity, and when the pumps were off the water flowed from the reservoir back into the distribution system.

There was no way of telling whether the water from the laboratory faucets was direct from the pumps or from the reservoir. Very likely it came from both sources. The laboratory faucet samples were collected daily, except Sundays, until a booster pump was installed at the filtration plant. After this, the laboratory faucet water was largely water direct from the filters. During the warmer months of the several years in which the samples were collected there was considerable increase in both the bacterial counts and the number of B. coli. The increase was more pronounced in some years than others, but there was always some increase each summer. One month in which there was not a single 10-cc. tube showing the presence of B. coli out of about 250 tubes in the water leaving the filtration plant, the laboratory faucet water showed 68 per cent of the 10-cc. tubes positive.

The portion of the city served by this pumping station and reservoir was largely residential, and so far as was known there were no cross connections with private supplies. The reservoir was open and the sides were lined with stone riprap. The water in the reservoir always stood above that of the surrounding ground, and any leakage would have been from the reservoir and not into it. The danger of pollution from the air was not great. It was known that microörganisms, such as algae, protozoa and rotifiers grew abundantly in the reservoir at times, but no systematic tests for such organisms were made. The writer came to the conclusion that the growths in the reservoir furnished the food for the bacterial growths. Several attempts to

determine if B. coli would increase in water containing microörganisms did not produce information of much value at that time.

Growth of B. Coli on Decaying Microörganisms.—It is only recently that evidence which appears to be fairly conclusive has been obtained on the growth of B. coli on decaying microörganisms. Raw water which received no treatment except to be chlorinated was passed through a closed glass tank at a fairly slow velocity. The water contained residual chlorine all the time, averaging about 0.2 part per million. The raw water contained an abundance of microörganisms, largely diatoms, which settled out quite readily and soon formed considerable deposit at the bottom of the tank. Tabellaria predominated in the sediment, but there were some melosira, synedra, asterionella, fragilaria, and a few other species of algae. There also were a few protozoa, rotifers, crustacea, etc., but about 99 per cent of the volume of the organisms present in the sediment were diatoms. With this water going into the pipes we should expect the same deposit of microörganisms to take place in the pipes at points where the flow is slow.

Part of the sediment in the tank was withdrawn with sterile pipettes and placed into chlorine-free sterile water. Examining with a microscope revealed a number of protozoa of an undetermined specie feeding on the vegetable matter. It is evident that algae cannot live in water containing so much residual chlorine, and it is likely that they were all dead before being deposited in the tank. Protozoa of the type found in the sediment probably could not live in water containing residual chlorine. It is likely that after the sediment became a certain thickness the residual chlorine did not penetrate through it and there was a zone of chlorine-free sediment.

Measured portions of the sediment were placed in broth tubes and in sterile water. The sediment after being removed from the tank was very soft and probably was at least 95 per cent water. About 75 per cent of the solid portion was composed of microörganisms. The counts were on agar plates, and the test for B. coli was in accordance with the usual procedure. In a few tests here it was known that all the bacteria present were B. coli, the counts were made on agar plates.

Table I.—Bacteria in Sediment Largely Composed of Dead Diatoms

Sample	Bacteria Per CC. 37°	20°	B. Coli Per 100 CC. Presumptive	Final	Per Cent of Tubes Showing Gas Which Are Postive to Methyl Red and Negative to Voges Proskauer
1	1,000,000	.....	16,000	175	60
2	575,000	3,900,000	17,500	300	33
3	465,000	.....	4,300	2,440	88

Table II—Increase in B. Coli When Plain Water and Water Containing Sterile Sediment Is Inoculated with B. Coli

Days Standing	Inoculated with B. Coli that Are Negative Both to Methyl Red and to Voges-Proskauer: 400 CC. of Sterile Raw Water	Inoculated with B. Coli that Are Negative Both to Methyl Red and to Voges-Proskauer: 400 CC. of Sterile Water with 30 CC. of Sterile Sediment	Inoculated with B. Coli that Are Negative to Methyl Red and Positive to Voges-Proskauer: 400 CC. of Sterile Raw Water	Inoculated with B. Coli that Are Negative to Methyl Red and Positive to Voges-Proskauer: 400 CC. of Sterle Water with 30 CC. of Sterile Sediment
0	540,000	240,000	23,400	18,000
1	1,245,000	13,800,000	58,000	4,250,000
2	1,750,000	41,000,000	900,000	11,750,000
4	1,570,000	28,250,000	400,000	17,750,000
6	1,835,000	28,800,000	.....	17,750,000
*6	2,500,000	25,000,000	350,000	16,000,000
12	1,850,000	32,500,000	2,235,000	20,775,000

*Number of B. coli estimated from broth tubes.

When broth tubes were used the McCrady system of determining the number of B. coli was used. Table I gives the results of 3 series of tests. For sample 1, the 10-cc. and 1-cc. portions of the sediment were measured direct, but diluted for lower quantities. Samples 2 and 3 were diluted before being inoculated, but the results are expressed in terms of the volume of the original sediment. The large number of B. coli that were positive to methyl red and negative to Voges Proskauer indicate that B. coli which are thought to be of fecal origin will grow on decaying microörganisms.

Determination of Growth on Sediment.—To determine if B. coli will grow in the laboratory on sediment composed largely of dead microörganisms, two 30-cc. portions of the sediment from the glass tank were sterilized in an autoclave and added to 400 cc. each of sterile water. To another 400-cc. portion of sterile water, 30 cc. of the sediment without sterilzation was added. The two flasks containing the sterile sediment were inoculated with B. coli taken from pure culture on agar slants. As soon as the B. coli were thoroughly mixed in the solution, samples were taken and plated on agar. The flasks were then stored in the 20° incubator. In addition to this, two 400-cc. portions of sterile raw water which contained a few diatoms were inoculated with B. coli from the same agar slants. These two samples are compared with the two containing 30-cc. portions of the sterile sediment in Table II. Table III shows both the count and the B. coli for sterile water inoculated with 30 cc. of the sediment from the tank which was not sterilized.

It is interesting to note a material increase in the B. coli when inoculated in plain sterile raw water. It is possible that enough of the media from the agar slant may have been transferred to the flasks in making the inoculation to give some food for the B. coli growth. It also is possible that the dead microörganisms, which probably averaged about 100 cubic standard units, were sufficient to produce or help produce the increase. At any rate the B. coli increased in the sterile raw water on standing whereas it was expected that they would decrease. The significant fact from the results shown in Table II is that the B. coli increased in the water containing the sediment to a very much greater extent than in the plain water and gives proof that the sediment at least furnished part of the food for the growth. Heating the sediment to sterilize it may have brought about changes in some of the organic compounds and this may have been partially responsible for such a great increase.

The growth of B. coli on dead microörganisms appears to be contrary to what is found naturally in most instances, but it may be that the reason why B. coli do not increase under such conditions as that they are prevented from growing by other organisms. It will be noted from Table III that the B. coli did not increase in the sample in which the added sediment was not sterilized. The water in this flash soon developed a very offensive odor of decomposition resembling that of the sludge in a sewage disposal plant. The general trend of the figures are downward on standing, and this perhaps is analogous to what takes place naturally in lakes and reservoirs.

There are a few types of organisms that grow in the dark, and where this is the case there may be times in which part of them die and furnish food for bacterial growths. The writer recalls while at Baltimore, the filtered water reservoir underneath the filters was drained for a few days. The water was not chlorinated on this reservoir. The sidewalls had a dark coating, largely manganese. Within this coating were micro-

scopical growths. Quite a large number of nematodes were found in the microscopical growths. After standing two or three days exposed to the air the odor of decomposition was very offensive throughout the reservoir. Microörganisms that do not live in the dark, when carried into the distribution system die and furnish food for bacterial growths, unless the water contains residual chlorine all the time. In cities like New York, Chicago, and Boston, where the water is not filtered, and where microörganisms are likely to be carried into the distribution system, it seems reasonable to expect occasional bacterial aftergrowths in any section of the city where residual chlorine is not maintained in the water. Any city having an open reservoir in which microörganisms are allowed to grow may have aftergrowths in the section supplied by the reservoir.

Bacterial Growth in Pipe Sediment.—To prove more conclusively that B. coli and other bacteria will grow in the sediment which accumulates in water pipes where the water contains microörganisms, another series of tests were run in which water containing microörganisms was allowed to flow from a faucet at the rate of about 200 cc. per minute. The water had been treated with about 0.5 part per million of chlorine, and that coming from the faucet at the slow rate of flow always contained residual chlorine. The residual ranged from 0.1 to 0.3 parts per million. This slow rate of flow was a pick-up of the sediment which had settled in the ¾ in. pipe leading to the faucet. It is believed that most of the microörganisms were killed by the chlorine. When the faucet was turned on nearly full force there was a pick-up of the sediment which had settled in the pipe, and the water would come out fairly turbid for a short period after increasing the rate. The sediment contained an abundance of microörganisms, most of which were diatoms. There were a few crustacea present, such as cyclops, bosmina and daphnia.

The procedure for testing was to collect a sample of the water in a sterile bottle for bacteriological tests while the flow was slow, also a sample for making a residual chlorine tests. About 10 cc. of sterile lactose broth, the same used for B. coli tests, were placed in another sterile sample bottle just before collecting the sample at the rapid flow. The faucet was then opened so that the flow would be rapid enough to pick up the sediment in the pipe, and the sample collected when the residual chlorine test. About 10 cc. of sterile lactose broth was to use up the residual chlorine immediately so there would be no danger of the bacteria in the sediment being killed. The plates and broth tubes were inoculated within a few minutes afterwards, and the broth placed in the sample bottle could not affect the number of bacteria. The results of the tests are given in Table IV.

It is evident that bacterial growths in water distribution systems are dependent upon the water containing food for the growths, and upon it being free from sterilizing agents such as chlorine. Water containing organic matter that settles or attaches itself to the side of the pipes may produce a coating so thick that even though the water contains considerable residual chlorine there will be a zone of chlorine-free water within the coating or within the sediment where bacteria may grow abundantly. Where the residual chlorine does not extend throughout the distribution system, as is the case for many water supplies not heavily chlorinated, there may be danger of bacteria increasing within the water if it remains in the distribution system for several days such as may be the case in some "dead ends."

About 12 or 13 years ago the writer conducted a series of experiments in which filtered water of fairly low organic content was stored in pyrex flasks in a 20 degree incubator. The flasks were cleansed very thoroughly. The oxygen consumed test on the water which was used was approximately one part per million, which is fairly low when compared with many water supplies. The water had been chlorinated, and the bacteria averaged less than 10 per cubic centimeter. The bacterial counts in the stored water remained low for about 48 hours, then they increased rapidly. After a period of from two to three weeks the counts were in excess of one million bacteria per cubic centimeter in most of the samples. The counts then gradually decreased. There was no increase in B. coli in any of the samples. This indicates that it is impossible to keep the filtered water from many supplies in the dark for several days without danger of aftergrowths, though there does not seem to be much danger of B. coli growing except in the presence of considerable organic matter such as decaying microörganisms, etc. Even then other bacteria grow so readily they usually prevent the B. coli from increasing

Table III—Growth of Bacteria in Water Containing Dead Microörganisms

30 cc. of sediment from glass tank added to 400 cc. of sterile water. Sediment not sterilized.

Days Standing	Bacteria Per CC. 37°	Bacteria Per CC. 20°	B. Coli Per 100 CC. Presumptive	B. Coli Per 100 CC. Final	Per Cent of Tubes Showing Gas Which Are Postive to Methyl Red and Negative to Voges-Proskauer
0	32,500	1,515,000	300	170	88
1	63,000	1,200,000	....	....	....
2	329,000	700,000	1,600	25	86
4	.....	.....	80	4	50
6	.....	.....	50	8	50
12	1,000	113,000	350	14	100

Table IV—Bacterial Content of Water from a Faucet Running Slow and Running Fast So as to Pick Up Sediment from the Pipe

Time Running at Slow Rate Before Collecting Sample	Water Passing Faucet at Slow Rate of Flow: Bacteria Per CC. 37°	20°	B. Coli Per 100 CC.	Faucet Running Fast to Pick Up Sediment: Bacteria Per CC. 37°	20°	B. Coli Per 100 CC.
1	1	0	0	8,200		70
1	0		0	17,500		130
1	1		0	20		8
1	0	0	0	500	250	2
1	1	0	0	35	850	4
1	0	0	0	4,200	120,000	35
4	3	2	0	300,000	90,000	1,600
1	1	2	0	20,000	26,000	7
1	1	2	0	2,500	3,000	11
1	1	1	0	1,100	12,500	8
2	0	3	0	12,500	90,000	1,800
1	2	1	0	4,100	19,500	0
1	0	1	0	40,000	74,000	50
4	1	0	0	35,000	45,000	13
2	0	0	0	70,000	48,000	4
1	0	0	0	4,200	4,800	2
2	1	0	0	4,250	4,000	0
1	0	0	0	40	250	0
1	0	0	0	5,300	5,500	0
1	1	1	0	12,500	16,500	5
1	0	1	0	1,800	2,000	5
5	1	1	0	8,400	22,000	8
1	1	1	0	700	550	25
1	1	4	0	100	90	7
1	2	2	0	160	200	8
2	0		0	210	325	2
1	0	0	0	10,000	11,000	25
1	1	1	0	130	180	50
1	1	1	0	220	180	2
1	1	2	0	4,000	11,500	40
3	0	2	0	250	7,500	11
3	2	1	0	30	11,000	2
1	6	8	0	75	55	5
1	20	20	0	20	250	2
1	25	14	0	180	180	0

materially. Either this is the case, or a special kind of food is required for B. coli growths. Fortunately the water does not remain long in the distribution pipes of some supplies, or the water would show a material increase in bacteria in passing through the distribution system. This increase is without sanitary significance except that should the water happen to become polluted the pollution might be attributed to natural increases and a dangerous situation might be ignored.

How to Avoid Bacterial Aftergrowths.—To avoid bacterial aftergrowths the water should be free from suspended organic matter or any matter that will form a gelatinous coating on the pipes such as manganese and iron, also it should be low in organic compounds that support bacterial growths. When it is not possible to produce water low in organic content the water should contain residual chlorine throughout the entire distribution system if an increase in the bacteria is to be avoided. It is easy to remove microörganisms and other suspended particles by filtration, but it is not easy to reduce the organic content of many waters to the point where it will not support bacterial growths.

No open reservoir should be connected to the distribution system of any water supply unless the water in the reservoir contains sufficient chlorine or other sterilizing agent to prevent biological growths all the time. Chlorinating the water leaving the reservoir may make it safe bacterially, but does not prevent microscopical growths that may later be food for bacterial growths in the distribution system. It was shown by Table IV that microörganisms depositing in the pipes may cause bacteria to grow abudantly even though the surrounding water has an excess of chlorine. Most of the troubles from bacterial aftergrowths in present water supplies may be avoided by the elimination of open reservoirs and the filtration of such supplies as are not now filtered.

Designing engineers should not under any ordinary circumstance recommend open reservoirs on a water distribution system. Confine the storage capacity to reservoirs that can be covered, and provide the desired fire protection by having sufficient storage capacity prior to filtration. With ample filtration capacity and sufficient duplication of pumping units excellent fire protection can be provided with a storage capacity of about 24 hours in balancing reservoirs. It would not be a burden on any city to cover such size reservoirs. Chicago, and a number of other cities have no elevated storage, yet they have excellent protection against fire.

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Water Works in Flood Areas

A paper on disaster preparedness plans for water works presented at the St. Louis Convention of the American Water Works Association by George W. Pracy, Superintendent City Distribution Division of the San Francisco Water Department, brought out much interesting discussion. An abstract of the paper is printed in this issue. Among the discussions was a contribution by J. H. O'Neill, Chief Engineer, Louisiana State Board of Health. This is reprinted below from the September Journal of the American Water Works Association.

One very important difference between earthquakes and floods, as we know them in the Mississippi Valley at least, is that we usually have warning of flood levels some time in advance and thus have time to prepare for the emergency. There are, of course, places where dangerous floods have occurred with as little warning as in the case of earthquakes. However, much of this discussion is applicable to plants wherever they may be located.

The problem may be considered from three viewpoints: location of plant, construction, and maintenance under disaster conditions. The line between these, of course, may not always be sharply drawn.

Even in the low areas subject to floods in the valley, there is sometimes a choice as to plant location. If possible, the plant should be located above the elevation of maximum flood level. In 1927, a certain motor driven power and pumping plant built to replace an old steam plant, and at a lower elevation, was flooded, while the reservoir, treatment plant and abandoned steam plant were unaffected. It would have been possible at a slight additional cost to build the new plant at the higher elevation.

If at an elevation subject to flood the plant may be protected by levees or in some places by closing door and window openings to the required height by brick or concrete walls. One important detail is to see that exhaust pits, or mufflers, for internal combustion engines are protected against flooding either by levee, wall or by elevation. The plant above referred to operated for some time with 3 ft. of water against the walls of the building, but failed when water entered the exhaust muffler pits.

Even with plants which do not normally use chlorine, provision should be made in advance so that chlorinating equipment may be installed quickly, and chlorine applied at one or more points in an emergency. State Boards of Health usually have portable chlorinators available. Manufacturers of such equipment are generous in furnishing equipment and personnel in disasters. Care should be taken to avoid overdosing with chlorine, since objectionable tastes and odors due to overdosing may lead people to use water from other sources which may be unsafe. Control of chlorine dosage by the orthotolidin test is simple and of great value. Material for this test can usually be obtained from the State Board of Health. Chloride of lime or hypochlorite solutions are usually obtainable from drug stores or laundries and may be used pending delivery of chlorine and chlorinating equipment. Plants using lime for softening can sterilize the water by overdosing to a caustic alkalinity.

Auxiliary sources of power should be provided, either by gasoline engines or supplementary power lines from other plants. The rapid development of "high lines" tying together power plants scattered over a wide area is helpful in this respect. Emergency equipment should include provision for removing seepage, waste waters, and wash water from filters. Motor driven fire engine equipment may be useful in an emergency and any necessary couplings for such use should be obtained and held as a part of reserve equipment.

Fire hydrants should be marked by flags to make them easy to find and to minimize possible breakage by boats. Red lanterns may be used at night if boat traffic in flooded streets is heavy.

Generous use of valves in a distribution system, so that sections with breaks may be isolated, is worth while in any system, but is particularly important in systems in areas likely to be affected by disasters.

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Joint Commission to End Pollution of Waterways.—Steps have been taken toward the creation of a commission to represent New York, New Jersey and Connecticut in formulating a treaty between the three states and the Federal Government to end the pollution of waterways.

New Activated Sludge Treatment Plant for the City of Woonsocket, R. I.

Several Novel Features Have Been Incorporated in the Design of This Plant, Construction of Which Was Started on July 5, 1930; It Is Anticipated That the Plant Will Be Completed and Placed in Operation by March 1, 1931

By PHILIP B. STREANDER

Associate Engineer, Remington, Vosbury & Goff, Consulting Engineers, Camden, N. J.

THE city of Woonsocket, R. I., has now under construction a sewage treatment plant of the activated sludge type, the effluent of which will be chlorinated and discharged to slow sand filters. Several novel features have been incorporated in the design of this plant which are worthy of description.

Woonsocket is situated on the Blackstone River in the extreme northerly part of the state. The river has quite an extensive watershed and flows in a circuitous course through the city, combining with several smaller streams to form the Seehonk River, which flows through and divides the city of Providence from Pawtucket and East Providence and empties into Narragansett Bay. The condition of the stream is naturally governed by seasonal variations in precipitation and temperature. During the summer months the dissolved oxygen saturation above the city averages about 70 percent. This is rapidly lowered in flowing through the city and zero saturations have been noted a distance of not more than a mile below the city. The reduction is caused almost entirely by the discharge of raw and partly treated sewage from an existing treatment plant and the discharge of a considerable volume of trade wastes.

The city has a total population of about 50,000 and is a typical industrial city, having some 87 industries employing about 15,000 workers. The industries are varied but consist principally of woolen and textile mills with their allied products. At the present time most of the wastes produced by the various industrial establishments are discharged directly into the Blackstone River, with little or no treatment. Upon completion of the sewage treatment plant, these wastes will be discharged into the city sewer system.

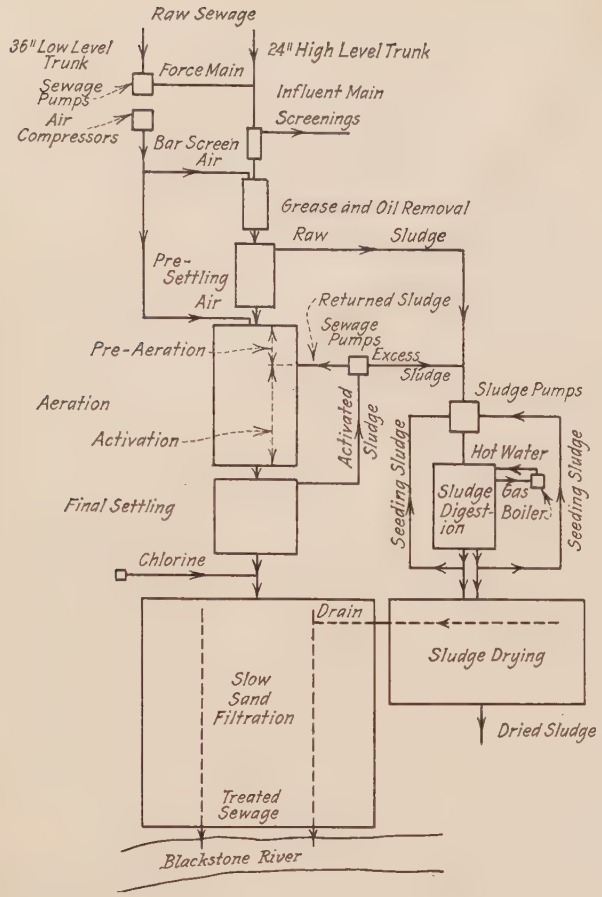
The city has a separate sewer system, consisting of about 55 miles of sewers ranging in diameter from 8 to 36 in., with a treatment plant situated in about the geographical center of the city. This plant was constructed in 1896 according to plans prepared by the late Rudolph Hering. The original plans called for two storage basins, a pumping plant and 5 acres of slow sand filters. For a population of about one-half of that now obtaining, it amply served the purpose. Later, additional sand filter beds were added, bringing the area up to a total of 10 acres, With a rapid growth in population and industrial extension the plant became utterly inadequate to treat the sewage reaching it, of necessity a part of the raw sewage was by-passed directly to the river and only that part of the total requiring pumping was discharged to the slow sand filter beds. The discharge of the raw and partly treated sewage and trade wastes directly into the river gave rise to gross pollution. During the summer months the dissolved oxygen content was reduced to a point sufficient to give rise to objectionable odors and caused a general nuisance to sight and smell. The condition necessitated the construction of a plant capable of meeting present-day demands.

As a result of various studies made, the conclusion was reached that the activated sludge process followed by sand filtration was the most economical and would best meet the conditions obtaining for this particular installation. One decided factor having considerable influence on this choice was the location of the plant. Being almost in the geographical center of the city, any plant constructed must of necessity be comparatively free from local and migratory odors. Another factor was the small loss of head required, causing a saving in pumping costs and in addition allowing for gravity flow of sewage to the plant from a comparatively large area of the city. Any other method would have, of necessity, required pumping.

Pumping Station Electrification.—In addition to the construction of the treatment plant, the existing pumping station will be equipped with electrically-operated sewage pumps and the station reconstructed into an administration building for housing the air compressor units and the testing laboratory. The pumps will be of the vertical motor-operated type, placed in a dry well and provided with non-clogging impellers. To meet the varying rate of flow in the sewer the pumping units will be of the variable-speed type, with automatic control equipment so designed as to pump sewage at approximately the same rate as the rate of sewage inflow to the station. Equipment of this type undoubtedly increases the average efficiency of the treatment process, as the discharge from the pumps is free from surges and irregularities and rates between minimum and maximum are effected gradually with no sudden fluctuations. The control equipment will automatically vary the speed of one or two units so as to obtain a varying rate of pumping between a minimum of 400 and a maximum of 4,200 g. p. m. A venturi meter is provided to indicate and record the volumes of sewage pumped and a depth gauge to indicate and record pump suction-well level variations.

Sewage pumped and that reaching the plant by gravity will combine in a junction manhole and will then flow through a mechanically-cleaned bar screen and a metering chamber in which an indicating, recording and totalizing gauge is provided to measure all of the flow reaching the plant.

Skimming Tank.—To remove most of the animal, vegetable and mineral oils present in a sewage of the character encountered, there has been provided an aerated skimming tank. This tank is provided with a central chamber in which are placed suspended air diffusers to agitate the sewage violently and cause it to flow over baffles into collecting and return chambers on each side. These chambers are provided with sloping bottoms connected to the central air chamber. The minute air bubbles and the agitation provided cause



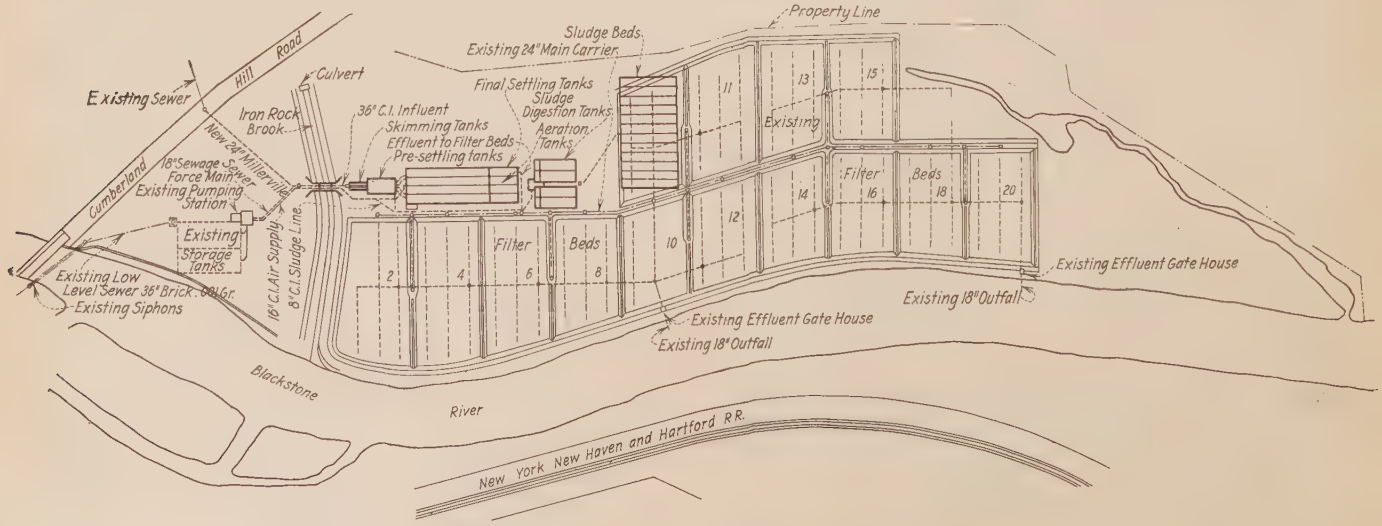
Diagramatic Arrangement of Sewage Treatment Process for Woonsocket, R. I.

partial saponification of the oils and greases. The mixture of air and saponified oil and grease, being lighter then the sewage, floats to opposite sides of the collecting and return chamber from which it will be skimmed into troughs. At normal flow the detention period is about 6 minutes.

Primary Settling Tank.—From the skimming tank the sewage is discharged into a primary settling tank designed to provide a detention period of 1 hour. Submerged tapered inlets are provided, discharging against a slotted baffle wall to distribute the sewage into the tank. The tank is divided into two separate compartments, each provided with mechanically-operated scrapers to remove the settled sludge, which is concentrated in storage hoppers and removed by means of a sludge pipe, operating under a hydrostatic head of 4 ft. Perforated piping is provided in the hoppers so that they can be periodically flushed down. Floating scum which may accumulate on the surface of the tank is removed by the return of the scrapers and concentrated at a scum trough located at the effluent end of the tank and so arranged that any floating solids can be easily skimmed off. The settled sewage discharges into a common flume in which there are provided four V-notch weirs which act as distributors and balancers to the aeration tank compartments. Means have been provided so that any predetermined volume of excess activated sludge can be returned directly to the influent end of the tank to assist in settling out the solids in the raw sewage and further to condition the sewage, a feature quite valuable where indstrial wastes enter the plant.

Aeration Tanks.—A somewhat unusual method of aeration has been provided in the aerating tanks. This consists of an "air-lift" changed having a width of 2 ft. constructed at one side of each compartment, in which there are located submerged air diffusers. The air diffusers consist of two 3-in. inside diameter porous refractory tubes, placed on 12-in. centers, 4 ft. below the surface of the sewage. The lower end of the air-lift channel extends to within 2 ft. of the bottom of the tank and sewage is forced upward through this opening by the heavier volume of sewage outside of the air-lift channel. The discharge end of the air-lift channel is provided with a throat arranged so that the mixture of air and sewage will flow rapidly across the surface of the aerating compartment. The aerating compartment is provided with deflectors at each turn to reduce friction and effect easy changes in direction of flow. It is estimated that the volume of air required to obtain a transverse tank velocity of 1.5 f.p.s. is 2.0 c.f.m. per lin. ft. of tank.

The tank is designed to provide an areation period of 6 hours with 25 per cent returned sludge and is divided into four separate compartments, each having a sewage depth of 12 ft., a width of 18 ft. and a length of 180 ft. By reason of the air-lift chamber it is essentially of the spiral-flow type. Compressed air, as previously stated, is introduced into the air-lift channel in each compartment through porous tubes placed 4 ft. below the surface of the sewage. The air is discharged into so-called units, each unit consisting of two 2-ft long porous tubes separated by means of an air-inlet casting, with the ends sealed by end caps and the assembly held together by means of a through bolt. One air-pipe connection is provided for two units, with a stop

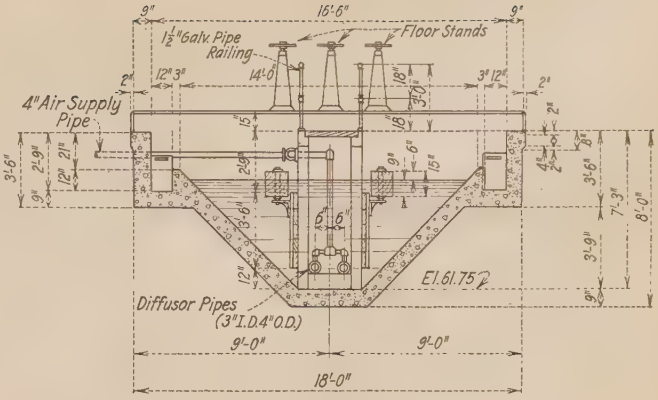


General Plot Plan of Treatment Plant, Showing Eixisting Slow-Sand Filter Bed

cock to regulate the volume of air or to cut the two units out of service so that they can be removed and cleaned. Two air manifolds are provided, one for each two compartments, and they are in turn centrally manifolded to secure even distribution of air to each lateral manifold.

The aeration tank is so designed that the point of applying the returned activated sludge can be readily varied. The tank volume preceding the application of the sludge will be used for pre-aeration of the sewage without any sludge. The object of this pre-aeration is to freshen up the sewage by driving off such toxic gases as the sewage may contain, which gases are deleterious to the delicate organisms which constitute the return sludge. Experience has demonstrated that comparatively short periods of pre-aeration without the return of activated sludge have reduced the biochemical oxygen demand by as much as 30 to 40 per cent. Each compartment is provided with four wood diaphragm walls to prevent short circuiting of the chore of the tank. In passing through the tank the sewage between the diaphragm walls must flow over or under these diaphragms.

As previously stated the volume of air required to secure non-settling velocities is about 2.0 c.f.m. per lin. ft. of tank. There being, all told, four compartments each 180 ft. long, or 720 lin. ft. of tank, the minimum air requirement for circulation is about 1,500 c.f.m. This is equivalent to about 0.70 cu. ft. of air per gal. of sewage. The sewage reaching the plant is somewhat stale and has an average suspended solid content of about 225 p.p.m., a free ammonia content of about 30 p.p.m., a chlorine content of about 72 p.p.m. and consumed oxygen 73 p.p.m. The foregoing are averages and are subject to considerable fluctuation. After completion of the treatment plant, the trade-waste flow will be considerably augmented by additional wastes from industries now discharging into the river. This will undoubtedly change the characteristics of the sewage and non-settling tank velocities will not be the determining factor in air requirements. Undoubtedly a considerably higher velocity of rotation will be required to expose the sewage to atmospheric contact for the absorption of oxygen. Sufficient air compressor



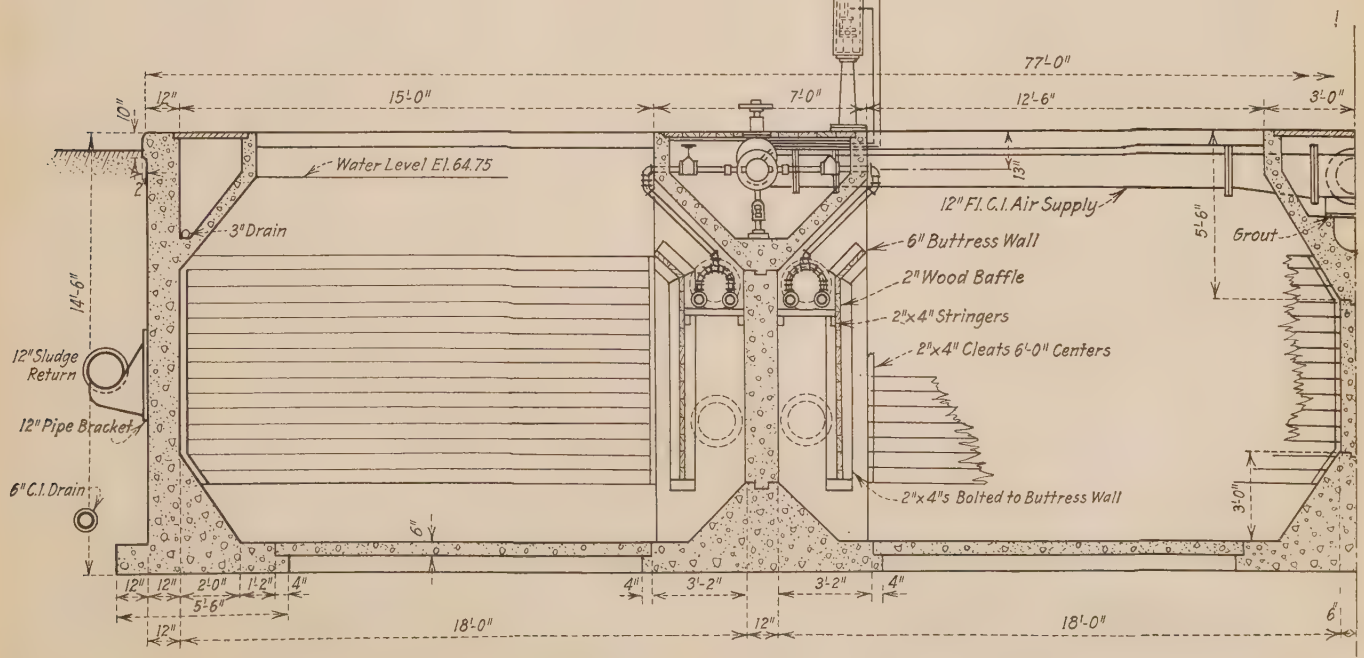
Section of Skimming Tank

capacity was provided to secure a maximum tank velocity of 4 to 5 f.p.s., requiring about 5.0 c.f.m. of air per lin. ft. of tank or a total of 3,600 c.f.m., this being equivalent to a maximum of 1.70 cu. ft. of air per gal. of sewage.

Air Compressor Plant.—The compressors are to be installed in what was the boiler room of the existing pumping station and will be in duplicate. They are of the high-speed single-stage type, developing a pressure of 3.0 lb. at 60 deg. F. Each compressor has a capacity at this pressure of 4,200 c.f.m. and is operated by an 85-hp. motor. Between 200 and 300 c.f.m. of air will be used in the aerated skimming tank, the remainder being available for the aeration tank. The pressure curves of these compressors are somewhat flat from the maximum capacity to the dropping-off point; therefore the power inputs between the two points give almost a straight line. The input to the motors in kilowatts for various capacities is as follows:

4,400 c.f.m.	76 kw. input
3,600 c.f.m.	63 kw. input
2,800 c.f.m.	50 kw. input
2,000 c.f.m.	37 kw. input

It is considered probable that the actual air requirement for the aeration tank will be about 2,800 c.f.m., requiring 50 kw. power input. This is equivalent to about 15 kw. per m. g. of sewage, which at prevailing



Half Section of Aeration Tank

power rates of about 1.45 ct. per kw.-hr. is equal to $5.65 per m. g. of sewage.

All air is filtered on the suction side of the compressors, for removing any dust or foreign matter contained in the air. The compressor discharge is passed through a venturi meter having an indicating, recording and totalizing register.

Final Settling Tank.—Aerated sewage discharges over a baffled weir into the final settling tank. This tank is divided into four separate compartments, each 18 ft. wide and 60 ft. long, and has an average depth below the sewage level of 9 ft. It provides a detention of about 2 hours at the nominal capacity. Settled sludge will be removed by mechanically-operated scrapers, concentrating the sludge in steep-angle hoppers located at the influent end of each compartment. These hoppers are provided with perforated water-flushing piping set around each hopper for periodic flushing.

Sludge is removed from each of the hoppers by means of a vertical sludge pipe, extending from the bottom of the hopper to a sludge withdrawal chamber, the bottom of which is 12 in. below the sewage level. An adjustable sludge decanter is provided which slides inside of the sludge riser pipe. This decanter consists of a short length of 10-in. brass pipe, having a V-notch weir cut in the pipe. The pipe slides in a machined flange bolted to the sludge riser pipe and the top is capped for attachment of a threaded stem operated by a floor stand. This decanter can be raised or lowered depending on the amount of sludge it is required to withdraw. A sludge channel is provided on each side of the sludge withdrawal chamber over each sludge hopper. One of the channels is used to return activated sludge to the aeration tank and the other channel to return sludge to the pre-settling tank, or, in case poor sludge develops, it can be discharged directly to the main sludge drain pipe.

Activated Sludge Return.—Activated sludge from the final settling tanks is piped to a sludge-return pump house alongside the aeration tank, from which it is pumped to each compartment of the aeration tank. The sludge pumps are of the vertical motor-operated type, operating at a low speed. Manually-operated variable speed control is provided so that the capacity of the pump can be regulated to suit the volume of sludge reaching the pumps. The discharge is manifolded to the sludge return pipes, one to each aerating compartment, and venturi tubes are provided in each connection having air-driven indicating manometers, so that the volume return to each compartment can be measured and regulated. A valved connection is provided for the discharge of excess activated sludge to the main sludge drain leading to the digestion tanks.

Final Treatment.—An effluent main is extended from the final settling tank to a main carrier pipe feeding the 14 slow sand filter beds. Chlorine solution is applied in the effluent main for sterilization, prior to the application of the tank effluent to the beds. Pre-chlorination will undoubtedly accomplish the dual purpose of bacterial destruction and the maintenance of the beds in a clean, fresh condition.

The purification effected by the slow sand filters will practically consist of additional nitrification and the straining out of the small non-settleable floc carried over from the final settling tank. The improvement to the tank effluent will, of course, depend almost entirely on the degree of purification previously effected. With a rate of application of between 300,000 and 400,000 gal. per acre per day, the beds will undoubtedly be of considerable value as final treatment, particularly during the summer months.

Sludge Treatment and Disposal.—All sludge developed in primary and secondary treatment will be disposed of by digestion in separate sludge digestion tanks. These tanks are of the high-temperature type provided with facilities for the collection and burning of the gas under gas-fired boilers, which with the heating coils maintain the sludge as its optimum digestion temperature.

Two separate units are provided, each divided into three separate compartments, each compartment being 15 ft. deep, 15 ft. wide and 90 ft. long. The sludge will be maintained at the level of the underside of the roof, to hold scum in a moist condition and prevent the formation of a hard scum layer. Mechanically-operated scrapers are provided in each compartment, with scrapers arranged to scrape the bottom and the underside of the roof, extending to within 30 ft. of the effluent end of the tank at the bottom and 15 ft. at the top. These scrapers will concentrate all loose scum at the inlet end of the tank, where it can be flooded with fresh water spray, supernatant liquor, raw or digested sludge or any combination of these.

The influent end of each compartment is provided with an elevated portion designed to act as an equalizer in the filling and drawing of sludge and also for the accumulation and removal of gas. Super- or subnatant liquor will be removed through an adjustable decanter consisting of a screw, on which a nut supporting an entrance casting is mounted. This is connected to telescoping pipe and and an outlet casting extended to an inspection manhole. The decanter is operated by means of a gas-sealed indicating floor stand mounted on the roof of the tank. Digested sludge is withdrawn from the effluent end of the tank through a valved outlet connected to an inspection chamber. From this it is piped to a manifold chamber arranged so that the sludge can be either discharged to the sludge drying beds or returned for seeding of the raw sludge. Supernatant liquor will be passed through this same chamber and handled likewise.

Gas generated during the digestion of the sludge is concentrated in the elevated portion of each compartment and is removed through a sealed outlet. From here it is piped to a condensation trap, gas meter, fire trap and to the boiler. A pressure relief tank is provided in the system for relieving pressure developed by an excess volume of gas. Each compartment is provided with heating coils, placed at the sides of the walls, above the center of the tank. Orifice-operated manometers and thermometers are provided for each compartment supply, so that the volume of hot water can be regulated for even distribution. The boiler is of the gas-fired hot-water type, having an A. G. A. rating of 3,600 sq. ft. equipped with the usual automatic heat control mechanism, etc. Motor-operated circulating pumps have been provided, having a capacity of about 6,000 g.p.h. Water meter, expansion tank, pressure relief valves, etc., have also been provided.

Raw sludge from the primary settling tank and excess activated sludge are piped to a pump sump from which the sludge will be pumped out and discharged into the compartments of the digestion tank. Digested sludge for seeding is piped to the same pump and mixed here with the raw sludge. To gauge the volumes flowing in, V-notch weirs are provided on each sludge line. A motor-operated dry feed machine is provided for feeding hydrated lime to the sludge for pH correction and sludge conditioning. Means are provided for draining sludge from any compartment to the pump sump, so that the sludge can be drained out or recirculated. A small building at one end of the two digestion-tank

units houses the heating apparatus, sludge pumps and dry feed machine.

Digested sludge from the digestion tank is piped to glass-covered sludge drying beds. These beds were constructed over one of the existing slow sand filters, using the existing sand and gravel for underdrainage. The bed is 240 ft. long and 125 ft. wide. It is divided into 12 separate beds, one-half of which are glass covered. The remainder of the bed is open, but walls and piers are provided so that the glass covers can be installed at a future date. Having open and glass-covered beds will afford an opportunity to demonstrate the advantages of glass covers in this section of the country.

A main narrow-gauge tank is provided to serve the beds, with switches and track for each bed. Rocker dump cars and a gasoline locomotive will be used to haul the sludge out of the beds. Dried sludge will be largely used by the city for conditioning its lawns and parks. Excess sludge will be used for the filling in of adjoining low land.

Cost of Construction and Operation.—The contract price for the construction of the treatment plant, the reconstruction and electrification of the pumping station, etc., is $360,000. The estimated cost of operation including power required for pumping the sewage, air compressors, sludge conveying and pumping equipment, chlorination, superintendence and labor required for the complete operation of the plan is $25,600.

Capacity of Plant.—The capacity of the plant was based on 1940 sewage flows from an estimated population of 60,000. The dry-weather rates of flow estimated from this population are as follows:

24-hour average flow	3.0 m.g.d.
12-hour-day rate of flow	3.9 m.g.d.
Peak hourly rate of flow	5.0 m.g.d.

During rainy weather these rates will be increased by additional ground and surface-water infiltration, as follows:

24-hour average flow	3.6 m.g.d.
12-hour-day rate of flow	4.5 m.g.d.
Peak hourly rate of flow	7.0 m.g.d.

The units of treatment were designed on the basis of 3.6 m.g.d., and on this basis the cost of construction per m.g. of capacity is approximately $100,000. The operating cost, based on an estimated 1935 daily flow of 2.5 m.g.d. of which 2.0 m.g.d. will be pumped, is $25.20 per m.g.

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Meter Reading and Billing at Hartford, Conn.

The following note is taken from the 1929 report of the Board of Water Commissioners of Hartford, Conn.:

The meter reading force consists of an assistant foreman and six readers. The territory is divided into 7 zones of which readings are taken every other month and billed semi-annually—the 7th zone comprising the larger meters, being read and billed monthly. Each reader averages about 90 meters daily.

Zone No. 1 is billed in Feb. and Aug.—Averages	3,574 meters
Zone No. 2 is billed in Apr. and Oct.—Averages	3,480 meters
Zone No. 3 is billed in June and Dec.—Averages	4,245 meters
Zone No. 4 is billed in Mar. and Sept.—Averages	3,868 meters
Zone No. 5 is billed in May and Nov.—Averages	4,302 meters
Zone No. 6 is billed in Jan. and July—Averages	3,089 meters

Each zone is placed in the mail the last day of the month and is due and payable the first day of the month following. On all water bills remaining unpaid twenty days after due a penalty charge of 5 per cent is added until the first of every month thereafter, when an additional 1 per cent is added to the 5 per cent until paid. The first of the following month after the bill is due a delinquency notice is forwarded to the owner of the premises, with a request to pay within five days. After this period, the account is turned over to the collector who gets in communication with the tenant occupying the house giving them an opportunity to pay the water charges, they in turn deducting the amount from their monthly rental. If the collector is unsuccessful, the water is shut off. Before the water is again turned on, all back charges must be paid, plus a $2.00 fee for the service.

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Fall Meeting New York State Sewage Works Association

The fall meeting of the New York State Sewage Works Association was held at the Onondaga Hotel, Syracuse, N. Y., Sept. 13, 1930.

Eighty members and guests were registered. Mr. C. A. Holmquist, President, presided and paid tribute to the memory of Kenneth Allen, founder and first president of the association. The announcement of the passing of Mr. Allen was a distinct shock to all present and the following a fitting resolution was adopted.

Resolution

The members of the New York State Sewage Works Association, assembled in meeting at Syracuse today, have been shocked and saddened by the announcement of the removal from our fellowship of our friend and first President, Mr. Kenneth Allen.

Many of us have had the advantage of personal contact and long friendship with Mr. Allen and recognize his sterling character, in his helpful criticism, his habit of thorough research and his sane and sound conclusions.

At all times he has preserved his kindly and helpful attitude and his sense of humor which endeared him to all his associates.

Therefore be it

RESOLVED: That we, his fellow members, in recognition of his life and work and his services to this Association, transmit this memorial to his family and spread the same upon our Minutes.

Following a brief business meeting, two papers were presented, one on "Chlorine Uses at Sewage Plants" by L. H. Enslow of the Chlorine Institute and the other on "Stream Pollution from the Operator's Standpoint" by Professor E. B. Phelps of Columbia University. The discussion of the papers was respectively opened by C. R. Cox and A. F. Dappert, both of the State Department of Health.

At the luncheon, Dr. George Ruhland, Health Commissioner of Syracuse, welcomed the members and gave a most interesting address on "The Relation of the Sanitary Engineer and the Health Officer in Community Health Protection."

In the afternoon an instructive inspection trip was made to the main sewage treatment works of the city of Syracuse, the Solvay lime wastes beds where the sludge is disposed of and to a small plant at Eastwood where separate sludge digestion and control were demonstrated.

After a dinner in the evening, a lively round table discussion with Vice President, Morris Cohn, presiding was held. R. S. Rankin, John F. Skinner and Harry W. Eustance led the discussion on the following topics, "Metal Preservation Above and Below Sewage Surface," "Garage Wastes" and "Experience with Small Pumping Stations." A paper prepared by Dr. J. F. T. Berliner on "The Ammonia-Chlorine Treatment of Sewage" was read by Mr. West.

The next meeting of the Association will be the Third Annual meeting and will be held in Albany at the time of the winter meeting of the New York State Conference of Mayors.

Tight Joints in Water Pipe Line

Tests of 18-In. Pipe Line for Water Supply of Frederick, Md., Showed Very Small Leakage

By C. J. REQUARDT

Of Whitman, Requardt & Smith, Consulting Engineers, Baltimore, Md.

THE City of Frederick, Md., recently installed about three miles of 18-in. cast iron bell and spigot pipe. Specifications for the work required a leakage under test of not more than 250 gal. per inch of diameter per mile of pipe per day. For the 15,000 ft. this amounts to 1.18 cu. ft. per minute. The specifications also required that the pipe be left uncovered uncovered until tests for leakage had been made.

The pipe was 18-in. deLavaud bell and spigot pipe as made by the U. S. Pipe & Foundry Co. Leadite was used for jointing material. The pipe was laid across country in a fairly straight line and with a cover of not less than 3 ft.

Immediately after the start of the work in the summer of 1929, the contractor urged that he be allowed to backfill over the pipe immediately upon laying and to fill the pipe with water as soon as successive points were reached where pipes could be capped or valved. The engineers, noting the careful work the foreman was doing and especially the excellent joints the pipe jointer was making, allowed the contractor to backfill immediately.

The pipe on installation was immediately put into operation. Test was postponed until the spring of 1930, about six months after completion.

How the Test Was Made.—In making the test, a centrifugal pump was used having characteristics of 50 gal. per minute at 3500 R.P.M. and 385 ft. head. It was a 2-stage pump, operated by a 25 HP. electric motor. Difficulty was experienced in the pump sucking air because the suction was attached to a pipe under but little pressure through one 1-in. lead gooseneck.

In starting the test it was found that the pump pulled air and gave false readings. The suction was then disconnected and three taps were made in the suction pipe and three lead goosenecks, each of 1-in. diameter, were placed. The pump was again started and as will be seen from the log of the test, the air trouble was eliminated and a good indication of the tightness of the line was obtained.

We expected small leakage due to the fact that the foreman and the city engineer the night before had run a 3-hour test under about 100 lb. mountain pressure which showed the leakage to be less than 30 gal. per minute. As this pressure was not sufficient, the test by the pump was deemed to be the official one.

As will be seen from the log, it was possible to obtain three 5-minute runs during the test in which the leakage was less than 26 gal. per minute.

Why the Line Was Tight.—Outside of the materials used, we look upon the tightness of this line as due to the careful blocking of the pipe; the cleaning of the bell and spigot ends; and the pride of the jointer in seeing that his jute was properly placed, with the pipes concentric with each other; that his jointing compound was uniformly heated and that all joints were poured without leakage and full in one operation. Further, we feel that the test was highly successful because the pipe was backfilled at once, eliminating differentials of expansion and contraction under action of the sun. Finally we believe that the pipe being filled with water and allowed to operate for a long period before the test was helpful in producing the tight line.

The pipe was installed under the advice of Whitman, Requardt & Smith, Engineers, of Baltimore, and Elmer StC. Maxwell, City Engineer. Ligon & Ligon of Baltimore were the contractors. Sam Wiederman was the superintendent and Clifford Cox was the pipe jointer. George A. Burke, is superintendent, and B. McCaffrey, is assistant superintendent of the Frederick Water Department. The illustration shows, in the front line, Messrs. Wiederman, McCaffrey, Cox, Maxwell, an inspector, Requardt and Burke.

The Testing Apparatus and Men Who Made the Test

Test of 18 in. Pipe of Frederick Water Supply, May 22, 1930

Meter in cu. ft.	Time	Cu. ft. per 5 min.	Cu. ft. per min.	Gage in lbs.
.....5057	9:08 A. M.	------	--------	----------
.....5061.5	9:13 A. M.	4½	0.9	230-40
.....5065	9:18 A. M.	3½	0.7	230-40
.....5069.5	9:23 A. M.	4½	0.9	230-40
.....5075	9:28 A. M.	5½	1.1	230-40

Bleed valve opened at 9:30 and meter went back to 5074 in ½ minute showing air had been forced into line. Up to this time gage had been vibrating 230-240 but now gage stands at 236 steady. This would indicate all air is out of line.

Meter in cu. ft.	Time	Cu. ft. per 5 min.	Cu. ft. per min.	Gage in lbs.
.....5076.67	9:33 A. M.	1.67	0.334	236
.....5077.33	9:38 A. M.	.66	0.133*	236
.....5077.80	9:43 A. M.	.47	0.094*	235
.....5078.5	9:48 A. M.	.70	0.140*	235
.....5082.5	9:53 A. M.	4.00	0.8	----------

At 9:52 A. M. we noticed the meter start to move rapidly and looking across the field one-half mile away, saw a laborer had opened a fire hydrant on 18-in. line. This was closed but the effect will show on next 5-minute run.

Meter in cu. ft.	Time	Cu. ft. per 5 min.	Cu. ft. per min.	Gage in lbs.
.....5088.5	9:58 A. M.	6.00	1.2	----------
.....5094.5	10:03 A. M.	6.00	1.2	230
.....5100.6	10:08 A. M.	6.1	1.22	230

These last tests show air in line due to hydrant opening. Owing to lack of water in the town, this test was stopped and the pipe accepted.

*These average 0.122 cu. ft. per minute, or 26 gal. per inch per mile per day.

Water Works Financing and Accounting

Some of the Principles of Proper Financing and Accounting as Applied to Water Works Practice

By H. G. CALDER

Assistant Comptroller, Federal Water Service Corporation, New York, N. Y.

THERE are in business, including the professions, three factors, which if the business is to be successful, must be taken care of, and the success of the business will be in proportion to the efficiency with which those three factors are administered. Those three factors are, production, selling and financing—which includes the accounting function. Any one factor may be broken down into other departments or all three may be handled by one man. I personally believe that the three are of equal importance to a business, but without prejudice in favor of my profession, if I had to choose from the three in a business where I had my capital invested to the neglect of the other two, I would unhesitatingly choose financing as the most important. Any business capitalized in a manner suited to it, maintaining proper financial position which spends less money for expenses than its revenue must be a success whether it be a peanut stand or the United States of America.

Finance.—In examining this factor in business called "Finance" let us first look at the financial structure of a business. It is the plan by which the business is built. Like any other plan it should be followed so far as possible, but should be subject to change where the original plan proves impractical. The main point is that any water works, either municipal or private, should make definite financial plans in advance; it should plan the most economical way of getting its original investment and the most satisfactory mode of handling its operating financial requirements. There are engineers who could build a dam, or lay a pipe line, without any plans whatever, because they have had so much experience that the plan is in their heads. Men with sufficient financial experience can do practically the same thing. But they usually choose to make their estimates in advance on paper and select whichever method seems most profitable. To do this, they must be familiar with the various methods which might be used. But either engineer or financier must rely on some kind of accounting method to give them the final cost of their completed project.

The accuracy of that accounting is the determining factor of the accuracy of their future calculations. It is possible to keep accounts on the backs of envelopes and keep them accurately, but it is quite difficult. I knew a German druggist once who did just that thing. He kept his accounts very neatly on the back of an envelope, and had the essential information that he needed to operate his simple business. But if he had understood how to enter the same information properly, in a ledger, he not only could have done it easier, but he would have had far more information about his business. May I say that he ran one of the smallest businesses there was in a town of 40,000 population.

Reports.—To determine proper policies, the management should have reports showing the status and progress of the affairs of the business. The information may be in the books and files of the office, but the treasurer or auditor of the business should present the important facts about the business in such a manner that they may be readily grasped by others interested in the management. It is worth while before deciding on the type of report to be presented, to investigate the type of report furnished by others and to examine their methods to find whether they are practical for your needs. In making any departure from proven methods, it is wise to get expert opinions, from those qualified by experience to advise. Proper reports are as important to management as charts are to a navigator.

The hope of civilization is that one generation will learn from the mistakes that previous generations have made. The hope of modern business is that we will learn not to repeat past mistakes, and that we will profit by using profitable methods again and again until something better is discovered. Business history is kept in the ledger, and that business history in many cases is just like civil war history. One story is taught in the North and another is taught in the South. There are some broadminded and well informed educators who teach both sides impartially, and lucky the student who learns his civil war history from such a professor, and lucky is the business which has an accounting system which presents the true history of that business, disregarding predetermined beliefs. Guessing can largely be eliminated from such a business.

Policies.—Businesses are run according to the policies of the management either expressed or otherwise, and determining policies for the management of a water plant without accurate accounting information is like buying a grab bag at a church fair, you don't know how good it is until you have closed the deal and its too late to back out. In the water business you know when you get your bank statement—the notice that your notes are due—or that your warrants are due and you can't sell your bonds. The only difference is that with the grab bag, the suspense is soon over. There is a water business with close to a million dollars revenue a year which is nearly 30 years old, and has never paid a dividend—due entirely to improper financing and fallacious policies based on erroneous accounting. The engineering has been satisfactory and the growth of the plant has been ideal for a profitable venture, but the forgotten factor beat them.

So much for theory. One of the strongest arguments for proper accounting is that in many instances modern methods of handling records actually save money in the operation of the office itself.

Examples.—Here are a few concrete cases of the thing we have been discussing. A certain water plant was acquired by Company A. The construction accounts were in miserable shape and had not been transferred to the fixed capital accounts for five years. Upon analysis, an amount in excess of $20,000, representing work which was for the account of an outside company was buried in these construction accounts. It was billed (after being lost for two years) to the consumer and collected. The total cost of that analysis was less than $500. In another case an audit of a company disclosed an error in accounting which made something over $17,000 available for dividends which would have otherwise been closed in its capitalization.

You have all read of refunds on federal taxes. You may be sure that in most cases they called for expert accounting analysis before they were secured.

One other story. There was a merchant in the lumber and grain business whose credit limit at the local bank was $3,000. The records which he kept of his business were negligible, he could never furnish his bank with a complete statement of his financial condition or of his profit and loss. As a result of the limit of his credit at the bank, he frequently lost discounts on invoices which ran as high as 25 per cent. He finally called in a bookkeeper. The bookkeeper put his records in shape and furnished him with monthly statements, copies of which were mailed to the banker. The banker as a result of receiving definite information, and as a result of the knowledge that this man was keeping records of his business, increased his credit limit to $10,000 and then to $20,000—with the result that the merchant made the difference between 25 and 5 per cent or $17,000 annually. After three years of keeping books he discontinued the grain business because his records showed that it had become unprofitable. His business and his personal financial standing improved amazingly through definite knowledge of his affairs.

When an issue of bonds for a water works is submitted to a banker regular statements and proper accounting may be a difference between 5 and 7 per cent in interest paid on the bonds and may also be the difference between being able to issue $500,000 or $1,000,000 of bonds.

Don't make guesses based on misinformation—get the facts. And do not run a one-horse business—put them all to work.

Acknowledgment.—The above is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

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Public Water Supplies and Unlawful Bathing

The Connecticut Supreme Court of Errors on April 17, 1930, handed down a decision regarding the protection of public water supply from contamination by unlawful bathing. The decision was rendered in the case of a realty company v. the Borough of Wallingford, et al. Public Health Reports for July 11, comments on the case as follows:

The plaintiff corporation owned land upon which was a small pond. Water from this pond flowed through a brook to the reservoir and pumping station of the borough of Wallingford. The plaintiff set apart, for use by the public as a park, about 150 ft. of the land all around the pond. The land back of this strip was divided into lots for sale. Large numbers of people were invited to come and bathe in the pond and the privilege of bathing therein was offered to the purchasers of the lots not bordering on the pond.

Section 2544 of the General Statutes provided as follows:

Every person who shall bathe in any reservoir from which the inhabitants of any town, city or borough, are supplied with water, or in any lake, pond, or stream tributary to such reservoir, or who shall cast any filthy or impure substance into such reservoir, * * * shall be fined not more than $100 or imprisoned not more than six months, or both.

The borough, through its water commissioners and superintendent of waterworks, called plaintiff's attention to the statute and also gave public notice that bathing in the pond would be a violation of the statute. Also the state commissioner of health caused notices to the same effect to be placed near the pond.

The plaintiff brought an action for an injunction to restrain the defendants—the borough, the water commissioners, the waterworks superintendent, and the state health commissioner—from interfering with the sale of its land and for damages. The borough filed a counterclaim, asking for an injunction against plaintiff's use of its premises as a pleasure resort or as a rendezvous for swimming, boating, or fishing or in a way that would render the waters unfit for water-supply purposes. The trial court found against the plaintiff in the action brought by it and in favor of the plaintiff on the counterclaim. The conclusions reached by the trial court were that the pond at the borough's pumping station constituted a reservoir within the meaning of section 2544; that the plaintiff's riparian ownership conferred only a personal and family privilege of bathing in the pond; that the proposed according of the privilege to the public and lot owners who were not riparian proprietors was an unreasonable use; and that, since the pond was entirely surrounded by land owned by the plaintiff, none of the lot owners was a riparian proprietor having, as such, bathing rights in the pond. The plaintiff appealed, but the judgment against the borough on its counterclaim was not appealed from.

The appellate court held that the judgment of the trial court was correct. Portions of the opinion follow:

* * * A riparian proprietor is an owner of land bounded by a water course or lake or through which a stream flows, and riparian rights can be claimed only by such an owner. They are appurtenant only to lands which touch on the water course or through which it flows and which are used as a whole for a common purpose, not to any lands physically separated from the stream and the land bordering on it, although belonging to the same owner. * * * It is clear that the grantees or contractees, from the plaintiff, of lots separated from and not bordering on Pine Lake can have, of their own right, no riparian privileges in its waters. And any attempted transfer of the right made by a riparian to a nonriparian proprietor is invalid. (Citations.)

Each riparian proprietor has an equal right to the use of the water to drink and for the ordinary uses of domestic life, although such use may in some degree lessen the volume or affect the purity of the water, and this right to such use extends "both to the owner himself and all living things in his legitimate employment." 27 R. C. L. p. 1085. The right includes use of water for drinking, culinary, and other domestic purposes, and for watering of animals. (Cases cited.) The right, being to use "ad lavandum et potandum," logically includes ordinary and reasonable bathing privileges by the riparian owner, his family, and inmates and guests of his household, in the stream or pond as well as in waters drawn therefrom. The trial court states, and the record indicates, that this right of the plaintiff was not questioned or involved in the present action; the proposed extension of the privilege to the plaintiff's grantees of lots and to the general public was the subject of the defendant's objection and notice of intention to resist. * * *

Each riparian owner is limited to a reasonable use of the waters, with due regard to the rights and necessities of other such owners. It is the common right of all to have the stream preserved in its natural size, flow, and purity, without material diversion or pollution. A riparian proprietor has no property in the water itself, but a simple usufruct while it passes along. Though he may use the water while it runs over his land, as an incident to the land, he can not unreasonably detain, divert, or pollute it, unless he has a prior or special right to some exclusive or particular enjoyment. He must use and apply the water in a reasonable manner and so as not to destroy, or render useless, or materially diminish or affect, the legitimate application or use thereof by other riparian proprietors. (Cases cited.)

Application of these rules readily demonstrates that the uses contemplated and threatened by the plaintiff clearly were extraordinary and unreasonable. * * * The conclusions reached by the trial court as to this feature of the case were warranted in law and fact.

* * * The giving of notice of intention to protect the supply by preventing the contemplated injury by promiscuous bathing was not only fair to the plaintiff and prospective purchasers, but a proper means of minimizing damages. (Case cited.) The notices were appropriate, also, to a fulfillment of the duty resting upon the defendants to adopt such precautionary measures as are reasonably proper and necessary to protect the community served by the water supply from risk of infection.

Water Supply System for Airports

A Timely Discussion of the Method of Solving the Problem of Providing Adequate Water Supply for Fire Protection Purposes for a Rapidly Growing Industry

By S. F. NEWKIRK, JR.

Superintendent and Engineer, Elizabethtown Water Company, Consolidated, Elizabeth, N. J.

THE task of furnishing an adequate and reliable water supply for air ports is one that is causing no little concern to those who are responsible for water supplies. The rapidly increasing number of airports with the presence of unusually inflammable materials, many having little or no water supply for fire prevention and extinguishment, has brought to the foreground in many localities the question of how these airports are to be supplied. A fire loss of $1,600,000 in 14 fires has also called the attention of the aeronautical industry to the fact that some means of combating fires must be provided at air ports.

Aerial Transportation Increasing.—Air transport, business aviation and commercial aeronautics are here, and here to stay. The federal government is developing an extensive system of national airways which bids fair to become in time almost as comprehensive as our national highway system. Powerful revolving search light beacons, with flashing course-light projectors for indicating the direction of the airway are being installed at 10-mile intervals. At thirty-mile intervals boundary-lighted intermediate landing fields are being established and equipped.

United States air transport routes now total approximately 37,000 miles, of which nearly 12,500 miles are lighted for night flying. All of these airways and navigational aids, however, would be useless if we had no airports, just as light-houses and other aids to marine navigation would be of small value if there were no ports or harbors in which ships could anchor and find shelter.

Adequate Airports Required.—Progressive cities are determined to have adequate airports to attract air commerce and its accompanying industries, as they recognize the fact that they must provide themselves with suitable air terminals if they are to have places in the great air transportation system that is rapidly spreading over the country. Chambers of Commerce, civic bodies, and municipal and county organizations are wide awake to the need for efficient airports, with the result that a large number of airports are being constructed and projected. In a few years the municipality that lacks a landing field for airplanes will suffer in prosperity and esteem. In 1929, government traveling airport specialists visited 636 cities and delivered 251 addresses in municipalities interested in obtaining airports. A carefully selected chain of airports established in or near all cities and the most important towns is essential to meet the needs for landing of the many planes now in constant use, and to care for the great increase in the near future.

The location of an airport has depended, in most instances, upon the field available and cost involved, whereas climatic conditions, visibility, prevailing winds and general surroundings play an important part in the space required. Most airports are located a reasonable distance outside of a city on an arterial highway or main line railroad providing rapid transportation to the center of the city.

The Growth of Areonautics.—To emphasize the growth of aeronautics, it is interesting to note that 4,761 military and commercial airplanes were produced in the United States in 1928, and 6,034 in 1929, and on January 1, 1930, there were 10,596 holders of pilot licenses and 31,391 holders of student permits. Aids to aviation in the next feedral budget, beginning July 1, are $22,517,630—about one-half the amount allotted to merchant marine. The total distance flown by all aircraft during 1928 was 65,658,936 miles.

On January 1, 1930, there were 1,603 municipal, commercial or private airports, Army and Navy stations, Department of Commerce intermediate fields and other marked auxiliary fields, an increase of 556 in two years. In addition, there are more than 4,000 fields owned by states, municipalities, corporations, clubs, commissions and individuals, on which landings may be made, but which are not permanently recorded, as they are constantly changing in character, and a permanent record would be of variable value. Also, in 1,274 cities additional airports of one grade or another are under discussion.

In the construction of an airport much time is given to the study of a proper layout, drainage, clearance, grading and surface lighting, but little or no thought is given to water supply.

The Fire Rating of Airports.—The Aeronautics branch of the United States Department of Commerce, in their rating of airports when considering fire-fighting equipment, are guided in a large measure by various standards of the National Board of Fire Underwriters. The National Board has not published any standards for protection of airports, and standardization must not come too soon in a field so overwhelmingly in its ascendency and so profoundly subject to revolutionary advancement. The National Board and the aeronautical industry have differences of opinion regarding fire protection requirements, and the National Board is now awaiting the outcome of various tests before publication of requirements.

An airport is often located at a considerable distance from a public water supply, and the cost of extending the system is prohibitive. The rapid rate at which water is required during a fire requires large mains, so that even when airports are near a public supply, they are sometimes at a remote distance from an artery.

An airport in New Jersey has had two fires with a total loss of $500,000 and, quoting from a local newspaper, "No water was available on the field and firemen were forced to lay several hundred feet of hose and draw on wells on nearby farms." The nearest fire hydrant to this field is 1.9 miles distant, and the nearest water system artery, a 36-in. pipe under eighty pounds pressure, is 10,000 ft. distant. To supply this field satisfactorily it would be necessary to lay an 18 in. line at a cost of about $60,000, and an elevated tank would need to be provided for reliability. Under utility regulations the private water company nearest this port would need to extend their system upon receipt of a deposit of about $15,000, refundable as other consumers connected to the extension. This company would

realize that an extension meeting the requirements of the utility commission would give little fire protection and the water company would be willing to add that much additional in order to give better service. If this latter extension were made and elevated storage of 50,000 gal. and a ground storage of 500,000 gal. were provided, there would be a sufficient supply.

Requirements of Water Supply.—Where airports are so located that it is impractical to obtain a water supply from an existing system, a supply will need to be developed. This supply will usually be from wells, as it is seldom that an airport is located near a surface supply that has any appreciable dry weather yield. It will also probably be costly to provide sufficient wells and well-pumping equipment to maintain the rate necessary for fire-fighting, so storage will need be resorted to. The quantity required which, of course, will vary in different ports, will probably be too great for elevated storage, so a combination of elevated and surface storage will need to be resorted to. The surface storage supply will need to be raised to the piping system by fire pumps. In all cases where an adequate fire flow can not be obtained from an existing system, storage, both elevated and surface, should be provided. The elevated storage should be sufficient to supply the required fire flow for about 30 minutes, and the combined elevated and surface storage should be sufficient to meet the requirements for a period of two hours.

Ground storage does not need to be in expensive concrete cisterns. Large wooden tanks similar to those used by the government during the war could be used. Fire pumps should be housed in a detached building of incombustible material. Electric power could usually be used for driving pumps with internal combustion engines for stand-by service. Water mains should be of cast iron and eight inches should be the minimum size, with larger sizes determined by carrying capacity necessary from source to point of use. Hydrants should be of sufficient size to meet the standards of the National Board of Fire Underwriters and where possible should be in a structure with hose attached. Care should be taken in selection of hydrant locations so as not to interfere with flying operations. Post indicator valves should be used as much as possible.

Construction Types at Airports.—In conjunction with the study for a source of supply, it is necessary to know just how much of a supply is necessary and, in order to estimate, it is necessary to decide what fire-fighting facilities are to be furnished. This depends upon the type of construction used for hangars and the features of heights and areas. The type of construction generaly used is frame, sheet metal and masonry walls, with a wooden roof supported on steel or built-up trusses. The masonry type of construction with some variations is generally employed by the larger transport companies and many of the cities that have more recently built airports. The sheet metal hangar is extensively employed, and frame hangars are found at the old landing field. In some cases, hangars are used for general shop and repair purposes, and, in such cases, mezzanines are frequently constructed to provide storage facilities. Frequently the hangar is constructed with lean-tos on two sides, housing repair shop, heating equipment, offices and rest rooms.

Heights are necessarily great, and the clearance from floor to bottom of lower chord of the roof truss is steadily increasing as the size of airplanes is increasing. The feature of height is important from the fire-protection view point, as it affects the design of sprinklers and the efficiency of hose streams. At present there are none other than single-story hangars, but the aeronautic interests state that space is at a premium and provisions should be made for two-story hangars and for basements beneath hangars. Basements are objectionable because they form pockets wherein vapors may accumulate.

The area of a hangar is necessarily important, as in structures of large area fire protetcion becomes a serious matter. A standard hangar area should be only moderately large and increases in dimensions beyond the standard should only be allowed where protective appliances are provided, which will, through automatic operation, extinguish many fires in their incipient stage. Of even more importance, if the fire is not extinguished, these devices, such as automatic sprinkler systems, will cool the air down below the ignition point of the material in storage and will largely clear up the smoke, so that men can enter and extinguish the remaining fire. The areas of the older hangars are relatively small, that is, 6,000 to 8,000 sq. ft., but in recent years areas of 9,000 to 14,000 are common practice. The tendency at present is to considerably increase these areas.

Sprinkler Systems.—The aeronautical industry does not regard the installation of automatic sprinklers favorably, but fire prevention engineers are of the opinion that the nature of the occupancy is susceptible to protection by automatic sprinklers, and no convincing reason has been advanced as to the inability of automatic sprinklers to cope with fires in hangars. The arguments being advanced against the use of automatic sprinklers in hangars are about the same as were formerly advanced against the installation of automatic sprinklers in garages, but in fires in sprinklered garages, over a seven year period, the sprinkler operation in 97.8 per cent of the fires was satisfactory.

Tests made at the Newark airport on a sprinkler system equipped with automatic, thermostatically-operated, quick-opening valves indicate that such equipment will successfully control airplane fires liable to occur in hangars, and such equipment, with ceiling and floor sprinklers, will probably confine a fire to one plane unless the fire starts between two or more planes at the same time, in which event it is likely that the fire would be confined to the immediately adjoining planes without involving others in the hangar, and serious damage to hangar structures is not likely to occur. This type of equipment requires a large volume of water, about 3,000 gal. a minute. In addition to an automatic sprinkler system, inside standpipes and hose and outside hydrants should be supplied.

The total quantity of water required for most airports would be an elevated tank of about 50,000 gal. capacity and surface storage sufficient to augment the normal supply so that three 1,000-gal. fire pumps could be adequately supplied for a period of about two hours.

The question of fire protection at an airport is a real problem and one that is not so easily solved as might be expected, but an airport is principally a public utility and is responsible for loss or damage to a plane while stored in a hangar. In many hangars signs are displayed to the effect that the owner of the hangar is not responsible for any loss or damage to the plant. This is, of course, no protection if the owner of the plane can prove negligence on the part of the hangar management and the same rule will possibly be applied by the courts to this question that now applies to the storage of automobiles in garages.

Acknowledgment—The foregoing is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

Installing a 30-in. High Pressure Main Under a 5-Track Railroad

Protection for Both Roadbed and Main Secured by 60-In. Corrugated Iron Pipe Conduit Installed Quickly by the Jacking Method

LAST summer an industrial plant situated near Euclid Village, O., completed the installation of an intake and main system which will make the unlimited supply of water in Lake Erie available for its use. The entire system, as now in place, consists of 12,000 ft., of which 2,000 ft. are installed on the bottom of the lake as an intake and 10,000 ft. on land as a connecting main.

The Problem.—In laying the 10,000 ft. of pipe on land, the engineer in charge was confronted with the problem of installing a 30-in. main under the main line of the New York Central Railroad, which is situated between the lake and point of consumption. Being a main line railroad between Chicago and New York, this is an extremely busy road and it was imperative that the method used of placing the main would in no wise interfere with traffic on the road, which at the point of intersection with the main consists of five tracks. For making this installation there were two possible methods: the open trench method, which would require shoring the track, the issuing of slow orders, and a period of maintenance for a soft roadbed after the installation was completed. The other method was to jack a corrugated iron pipe conduit under the track and lay the pipe in the opening thus created.

Methods Considered.—A study of both methods revealed that the Armco jacking method would eliminate such bad features as slow orders, track maintenance and expensive shoring of the track. The estimated cost of both methods also showed a large differential in favor of the jacking method.

In making such an installation under a railroad which carries a large number of fast trains, the safety of workmen is an element to be considered. By using the jacking method all work is done below the level of the track, thereby practically eliminating the possibility of an accident from passing trains.

With these advantages to be gained from its use, the jacking method was chosen to make the installation. Armco corrugated iron pipe was chosen as the conduit because its long sections are particularly adapted to placing by this method.

Method of Installing the Conduit.—The first step in the installation was the digging of an approach trench to the level of the proposed line on the lower side of the track. In this trench the regular jacking setup, consisting of lining timbers set to an accurate line and grade, a backstop for the jacks, and a bearing frame to transmit the pressure from the jacks to the pipe, were placed.

When the jacking setup had been completed a section of 60-in. pipe, which was provided in 16 and 18-ft. sections, was lowered into place and excavation ahead of the pipe started. The material encountered was a

General Layout with Shovel Digging Approach Trench. The Pipe Jack and Bearing Frame Are on the Job Awainting Use

Fast Railroad Traffic Passed Over the Tracks at Regular Speeds While the Installation Was in Progress

hard virgin clay for the lower 60 per cent of the pipe and a clay embankment for the upper part. Both these materials had a sufficient amount of stability, which is important to the ease of installation by this method. As the excavation of an opening just sufficient in size to admit the pipe was completed, pressure was applied by the jacks and the pipe was forced into the embankment. When the first section was jacked completely under the track in this manner, the second section was lowered into place on the lining timbers and connected to the first by means of a field riveted joint and the jacking resumed. This process was repeated until a total of 100 ft. of pipe, the amount required to carry the main under the track, was jerked into place.

Using a 60-in. pipe as a conduit in this case gave ample room for laying a 30-in. main which was carried under the track without further delay.

Railroad engineers and inspectors who visited the job from time to time, were well pleased with the numerous features which this job presented towards the maintenance of traffic schedules, the lowering of costs during and following installation, and the assurance of safety it gives from a broken main.

Frank Thomas, engineer of Euclid Village, was responsible for the design and execution of the entire project. Charles W. Jackson, of Cleveland, was contractor for the job.

Michigan Water Purification Conference

The 5th annual Michigan Conference on Water Purification will be held Oct. 20, 21 and 22 at the Hotel Durant, Flint, Mich. The program is as follows:

Monday Morning

Introduction of Members.
Paper "Filter Gages"—Douglas Feben, Detroit

Afternoon Session

Paper "A Year in the Mt. Clemens Filter Plant"—Harry McEntee
Paper "Water Bacteriology"—Prof W. L. Mallmann, Michigan State College
Discussion—R. Sensabaugh, Use of Phenol Red Lactose Broth
Discussion—Department of Health Experiments with Simmons Citrate Agar

Tuesday Morning

Round Table—Plant Problems
Experiences with filter washing—H. W. Ward
Experiments with coagulants—C. Howard
Reconditioning Filters at Highland Park—Irving Dahljelm
Reconditioning Filters at Grand Rapids
Cross connections surveys—W. D. Loreaux
Business Session

Afternoon Session

Inspection Trip
Possibly a Golf Tournament

Evening Session

7:00—Banquet—Harry C. McClure, Toastmaster
John N. Edy, City Manager, Flint
H. S. Streeter, U. S. Public Health Service, Cincinnati, O.

Wednesday Morning

9:00 Paper—"Water Softening"—Walter A. Sperry
10:30 Paper—"One year's operation of the Saginaw plant"

Wednesday Afternoon

1:30 Paper—"The present status of the Taste Problem"—L. B. Harrison
2:30 Paper—"Taste Removal Problems at Pontiac"—R. A. Hoot.

John M. Hepler of State Department of Health, Lansing, Mich., is secretary of the conference.

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Ground Water in Southern Idaho

An investigation to determine the geology and underground water resources of the Snake River lava plain, an area of more than 16,000 square miles in southern Idaho, was begun in May, 1928, by the Geological Survey, Department of the Interior, in cooperation with the Idaho Bureau of Mines and Geology, Idaho Bureau of Reclamation, North Side Canal Co., Twin Falls Canal Co., Minidoka Irrigation District, and Idaho Power Co., under the general direction of Harold T. Stearns. An advance set of maps showing the direction of movement of the ground water under this vast plain and the location of the wells from which the measurements were obtained was released for public inspection August 15, 1929. The final maps for publication are now completed, but because the report can not be published for some time copies of the maps have been made available for public inspection at the district offices of the United States Geological Survey, 228 Federal Building, Idaho Falls, Idaho, and Federal Building, Boise, Idaho; the office of the Commissioner of Reclamation, Boise, Idaho; the office of the Bureau of Mines and Geology, Moscow, Idaho; and the main office of the Geological Survey, Washington, D. C.

Is Cloud Stratification Due to Series of Electron and Proton Shells?

By HALBERT P. GILLETTE

THE "Heaviside layer" is a shell of electrons about 26 kilometers (43 miles) above the earth's surface I have recently shown that by assuming that series of electron shells surround the sun, Bode's law as to the solar distances of planets can be explained. The same explanation applies to a similar law as to the distances of the moons of Jupiter and Saturn from those planets. In those cases there appear to be two series of electron shells, or perhaps alternating electron and proton shells, each series forming a geometrical progression in which the ratio is two. Finding this to be the case as to the distances of satellites, I inferred that clouds might exist in strata, whose distances from the earth's surface would form a geometrical progression. This inference was verified by data in Clayton's "World Weather."

On pages 160 and 168 of that book there are charts and tables from which the following facts have been taken. Nimbus clouds are most frequent at a mean height of about 700 meters (2,296 ft.); cumulus clouds at 1,400 meters; alto-cumulus at 2,600 meters. Here we see a well defined tendency of these clouds to be most numerous at elevations that are approximately terms of a geometrical progression series whose ratio is two. The strato-cumulus clouds are most numerous at a mean height of amout 1,080 meters and the cirro-status at 8,600 meters, which ratio is approximately 1 to 8, thus indicating another geometrical progression.

If we divide the 700 into the 1,080 we get a ratio of about 1.6, which is very nearly the same ratio that I found for corresponding terms in the two series of distances of the planets from the sun and the satellites from the planets.

It is noteworthy that the wind velocity in these cloud strata is greater than that between the strata. This is explainable by the theory of electron-whirls, which I have advanced to explain cyclonic storms.

Clayton points out that high clouds usually appear before the lower rain clouds arrive, and that this sequence can be used in forecasting rain 24 hours ahead. He also shows that the upper clouds that form in sheets are usually inclined to the horizon, the inclination being downward when they are in advance of a storm, and upward when they follow a storm. He infers that the air ascends obliquely upward, but the electron theory offers a different explanation. Any shell of electrons or protons in the air is itself a magnet as a result of its rotation with the earth. Moreover it probably contains many cyclonic whirls each of which is a magnet; the whole forming a compound magnet. Hence, when the axis of any powerful magnet, such as the sun, a sunspot or a planet, lies in a position most favorable to pushing or pulling these terrestial magnetic whirls, there must result either an upward or downward motion. During a storm the whirls in an electron shell move upward, thus cooling the air that is carried with them, and causing increased cloudiness and ultimately precipitation. The downward inclination of the advancing upper layers of clouds, to be seen in Clayton's sketches, is evidence of an upward bulge of the electron shells beneath and to the rear. Contrariwise as to the upward inclination.

Ever since Sir J. J. Thomson used electrons to form artificial clouds in his laboratory experiments, it has been certain that electrons are factors in producing rainfall, but most meteorologists have hitherto regarded a study of electrons as being of little practical importance in meteorology. Clayton (p. 156) says: "Aitken has shown that condensation in (water) particles cannot take place without a nucleus, which is generally furnished by the fine dust in the air, although it is now considered that electrons or ions may also be nuclei. Without these nuclei supersaturation would be possible and when condensation began the water might fall in sheets, but as abundant nuclei are always present this condition has only a theoretical interest." I believe, on the contrary, that variation in electron density in the air is not only a matter of theoretical but of practical importance.

The existence of two doubling series of shells surrounding the earth seems to be best explained by assuming one series to be electron shells and the other series to be proton shells. This hypothesis may also be used to explain the periodic reversal of sunspot rotation. A table of cloud elevation and average cloud thickness on p. 168 of "World Weather" shows that the cumulus clouds are ordinarily twice as high and half as thick as the nimbus clouds; but this inverse relationship of thickness to height does not apply to the strato-cumulus clouds whose elevation is intermediate between those two, for the average thickness of the strato-cumulus is half that of the cumulus. If we regard the nimbus and cumulus clouds as being caused by electron shells, and the strato-cumulus by proton shells, a reason for this difference in cloud thickness emerges. The electrons are negatively charged and the protons are positively charged, and there may consequently be a difference in their respective effects on condensation of moisture.

While the word "shell" is a fairly good one to designate the Heaviside "layer" of electrons, and the like, it should not be inferred that the electrons in such a shell are all rotating with the same angular velocity. It is more likely that each shell is composed of somewhat independent zones of electrons, for the difference in velocity of the "belts" of Jupiter indicates a zonal grouping of its atmosphere. Similar zonal arrangements exist in other planets.

If there is a doubling distance series of electron shells surrounding the earth, the first shell having a mean elevation of 700 meters, then there should be a shell having a mean elevation of about $32 \times 700 =$ 22,400 meters. The Heaviside layer is about 26,000 meters above the earth, and therefore approximately fits this doubling distance series.

In another article I have pointed out that the length of time between radio echoes indicates the existence of two doubling distance series of electron (or electron alternating with proton) shells. Magnetic pulses, measured by magnetographs, also indicate the same series of shells. Hence the existence of cloud strata forming two doubling distance series serves to establish more firmly this electron and proton shell theory.

Doubling distance series are to be found both in planets and the satellites of planets, thus adding striking evidence of the intimate relationship between the earth and other members of the solar system. Such

relationships serve to emphasize the importance of not confining one's meteorological researches to phenomena on this globe of ours. Conversely such relationships indicate how an astronomer may learn more about sunspots by studying terrestrial air-whirls. Even the existence of invisible planets may be proved by weather cycles that are scribed in geological strata. The boundaries by which we have fenced off our departments of science are purely artificial. Therefore it is wise at times to push aside all man-made fences.

Financial Statistics of City Governments for 1928

The Department of Commerce announces a summary of the financial transactions of the 250 cities having a population of over 30,000 for the fiscal year 1928.

The total payments for operation, maintenance, interest, and outlays for permanent improvements for cities having over 30,000 population were 79.8 per cent greater than similar payments of the government of the 48 states, and 0.8 per cent less than those for the Federal government for the fiscal year 1928.

Preliminary statements for each of the cities have been released for publication as rapidly as the reports were received, the first of these statements appearing March 8, 1929. A summary, by cities, will be available within a few weeks giving financial statistics which will show assessed valuations and tax levies, revenues collected, governmental-cost payments, and indebtedness.

Expenditures.—The payments for operation and maintenance of the general departments of the city governments of the 250 cities for the fiscal period 1928 amounted to $1,853,232,348 or $42.63 per capita. In 1927 the comparative per capita for operation and maintenance of general departments was $40.98, and in 1917, $19.07. Payments for the operation of public service enterprises, as waterworks, electric light plants, and similar enterprises amounted to $164,154,462; interest on debt, $342,100,311; and outlays for permanent improvements, including those for public service enterprises, $1,036,635,298. The total payments in 1928, therefore, were $3,396,122,419; in 1927, $3,324,386,351; and in 1917, $1,108,021,565.

The per capita net governmental-cost payments for operation, maintenance, and interest for 146 cities covered by the various census reports since 1903 were $54.43 in 1928, $52.64 in 1927, $24.58 in 1917, and $16.41 in 1903.

The total include all payments for the year, whether made from current revenues or from the proceeds of bond issues. Proceeds from the issuance of debt obligations are not considered revenue receipts.

Of the 250 cities covered by this report only two were lacking in revenues sufficient to meet all operating expenses and interest, while 68 realized enough revenues to meet all their payments for expenses, interest, and outlays and to have a balance available for paying debt.

Of the total municipal payments in 1928, 54.6 per cent was for operation and maintenance of general departments; 4.8 per cent, operation and maintenance of public service enterprises; 10.1 per cent, interest on debt; and 30.5 per cent, outlays for permanent improvements.

Of the payments for operation and maitnenance of general departments 38.4 per cent was for education; 19.7 per cent, protection to person and property; 8.6 per cent, general government; 8.5 per cent, highways; 7.6 per cent, sanitation or promotion of cleanliness; 6.4 per cent, charities, hospitals, and corrections; 5 per cent, miscellaneous; 3.4 per cent, recreation; and 2.4 per cent, conservation of health.

The percentages for 1928 show but little change from those for 1927, the largest in each of the years being for education and the smallest for conservation of health.

Of the total payments for outlays for permanent improvements, the principal items were 389,688,125, or 37.6 per cent, for highways; $178,675,794, or 17.2 per cent, for education; and $156,135,016, or 15.1 per cent, for public service enterprises.

Revenues.—The total revenue receipts for the 250 cities for 1928 were $3,114,169,311 or $71.64 per capita. This was $754,682,190 more than the total payments of the year exclusive of the payments for permanent improvements, but $281,953,108 less than the total payments including those for permanent improvements. The revenue receipts included $1,993,265,137 from general property taxes; $69,956,211 from special taxes; $95,487,471 from license taxes; $249,562,380 from special assessements; $166,289,426 from subventions, donations, and pension assessments; $140,656,885 from interest, rents, and highway privileges; $297,957,505 from earnings of public service enterprises; and $100,994,296, the remainder, from poll taxes, fines, forfeits, and escheats, and earnings of general departments.

The per capita net revenue receipts of 146 cities covered by the various census reports were $72.11 in 1928, $69.77 in 1927, $31.97 in 1917, and $21.14 in 1903.

The net indebtedness (funded or fixed debt less sinking fund assets) of the 250 cities amounted to $5,828,141,561, or $134.07 per capita, in 1928, this being an increase of 6.4 per cent over that for 1927. The per capita net debt of 146 cities covered by the various census reports was $139.63 in 1928, $134.27 in 1927, $80.75 in 1917, and $44.71 in 1903.

While there was an increase of $337,288,881 in net debt for the 250 cities as a whole, 113 individual cities showed a decrease in their net indebtedness.

A comparison of the aggregate increase in net indebtedness with the total payments for outlays discloses the fact that 32.5 per cent of the permanent improvements for 1928 were financed from proceeds of bond issues.

Assessed Valuations and Tax Levies.—For 1928 the assessed valuation of property subject to ad valorem taxation for city purposes was $77,849,280,583 for the 250 cities having over 30,000 population; and the amount of taxes levied for the city governments was $2,100,823,905, or $48.33 per capita.

Independent Divisions.—These statistics cover the government of the city corporation proper, and also independent school districts, sanitary districts, park districts, and other independent districts practically coextensive with the cities. They also include a per cent of the financial transactions, debt, and tax levies of the county governments for cities having over 300,000 population, in order that the statistics for such cities may be comparable with those for other cities in this class in which the ordinary county functions are performed by the city government.

Annual Meeting of Pennsylvania Water Works Association.—The 35th annual meeting of this association will be held Oct. 22, 23 and 24 at Atlantic City, N. J. F. S. Purviance, Room 327, Telegraph Bldg., Harrisburg, Pa., is secretary.

Mechanical Accounting for Municipal Water Works Departments and Companies

The Application of Machine Accounting and a Rough Idea as to Their Value and the Savings to Be Obtained by the Adoption of Such Methods

By P. H. HUTCHINSON
Public Service Division, Burroughs Adding Machine Co.

THE various classes of accounting work discussed in this paper are distributed somewhat as follows:

	Per Cent
Customers Accounting	50
Payroll Accounting	15
Materials and Supplies Accounting	15
Accounts Payable	8
General Records	8
Reporting Work	4

When the assistance of machines was considered it was first applied on the largest group of work; namely, Customers Accounting. The adoption of mechanical accounting in this department has been very popular and is today almost universal. It is considered that it pays to use large machines whenever the number of meters to be handled exceeds 3,800 per month. Smaller machines with fewer automatic features are available at a very reasonable price where a smaller number of meters are in service.

Many of the large utility groups and also many of the individual companies have gone further than to simply introduce machines on this work by divorcing themselves from ledgers in favor of what is known as the "bill stub plan" or "Baltimore Plan of Bookless Bookkeeping."

Advantages of Machines.—Let us consider what the attraction has been that has drawn so many to use machines on customers accounting. The answer is the old slogan of "Improved Production at Decreased Costs." The improvements are:

First—Neatness: Better looking bills and more legible internal records.

Second—Accuracy: The bill, cashiers coupon, and ledger record cannot differ; the consumption is proved to be the difference between the readings; the extension of the quantity used by the rate applicable is guaranteed and the revenue is certain because it is the amount of each bill added as it is printed.

Third—Control: There is a stipulated total of what bills have been sent out and any defalcation can be easily detected because cash received plus uncollected accounts must check to the amount of bills printed.

Fourth—Speed: The machines used can prepare the bills, coupons, ledgers, and revenue statistics at a production of from 700 complicated accounts to 3,000 simple single line accounts per machine per day.

Savings from Mechanical Accounting.—While all of these very desirable results are being obtained, money is being saved as the accounting cost can be reduced on an average of about 25 ct. per account per year. On that basis, on 10,000 accounts about $2,500 can be saved each year. When a main extension is considered the popular ratio is that the investment should not exceed five and a half times the return. That means at a 50 per cent operating ratio to earn $5,000 gross revenue or $2,500 net, the justified investment would amount to $27,500. To earn the same net return with a Customers Accounting installation, using the most up-to-date equipment, the investment would not exceed $6,000 including the billing machine, automatic addressing equipment with plates and plate cabinets, binders for ledger stubs, fireproof filing equipment and automatic stamping and sealing equipment.

Mr. John L. Conover of the Public Service of New Jersey, who have about 1,200,000 meters, states in a paper on Customers Accounting that his organization realized a saving in labor alone of $300,000 per year by introducing a machine operated stub plan.

A private water company with 18,000 customers saved about $12,000 per year by introducing the same system and at the same time changing over from monthly to quarterly staggered billing.

Many water departments and companies have installed machine methods on their customers accounting work obtaining additional results and at the same time realizing a saving sufficient to cover their equipment investment in from one to two years.

Utilities that had obtained such desirable results on their largest group of work naturally turned their attention to the other half of their accounting problem, applied the same principles and obtained the same results.

Application to Payroll Accounting.—Let us take Payroll Accounting as the class of work next in importance. To get the best results from personnel the employees must have 100 per cent confidence in the company and the men they work for. If an employee does not receive his or her pay check regularly and without waiting, that confidence which is so important and valuable is undermined and often ruined. A company or department of any size by using machine methods on payroll work can have available before the end of the following day the earnings of each employee, for the period to date, and the accumulated labor expense charge to each account, for the month to date. When it comes to pay day there is no tedious work to be done, no errors to be made in the rush and no overtime is necessary to get the pay checks to the staff on time.

The original data from the timekeeper goes direct to a machine operator who extends the hours worked by each man on each account at the man's rate. The machine product being in units is sorted and posted two ways. First, to the man's accumulated earnings to date and second, to the accumulated expense charges to date by accounts. When it comes to pay day the work is very simple and straightforward. Machines are in use which prepare at one time at the rate of up to several hundred per hour all the necessary records:

1. The Employees Statement of Wages.
2. The Pay Check.
3. The Employees Income Tax and Earnings Record.
4. The Payroll List.

5. The Check Register Sheet for reconcilation with the Payroll Bank Account.

These machines accumulate the gross pay, make the necessary deductions, ascertain the net pay, and print and protect it on the check together with the date and consecutive check number. At the same operation the gross pay, net pay, and deductions for all employees are added and totaled. If payrolls are paid by cash the same routine can be followed except that a pay envelope is printed instead of a pay check.

Materials and Supplies Accounting.—These are handled in much the same way as the payroll. All receiving reports, issues and returns come to the office in skeleton form showing only the class of stock and quantity and are priced and extended by the machines. Totals are added while this extending is done to get the day's cost figures and to obtain the figures to control the postings to the stock records and distribution cards. All postings to the stock records and distribution accounts are made by machine and all work is balanced as it is performed. Each month, if desired, an inventory list is prepared and the whole or any part of the physical stock can be verified. Material accounting is one that has always presented a ticklish problem from the point of control and it is often difficult to ascertain whether shortages are due to defalcation, carelessness in not preparing issue tickets or poor accounting. The adoption of machine methods on this class of work has made large strides in the right direction by making the accounting fool-proof and thereby pinning the responsibility for any shortage on the storekeeper, who, in turn, is going to be more particular about getting a signature for everything that goes out of his store.

Accounts Payable, General Records and Reporting Work.—Up to this point we have considered methods of handling 80 per cent of the accounting problem. The remaining 20 per cent covers Accounts Payable, General Records and Reporting Work. The size and type of the company or department would decide the machine requirements on these activities. Where the quantity to be handled is large enough, special machines can be used, but the work can be just as easily done on the payroll or materials machines by the addition of special features to handle any additional operations.

In the small utilities where the volume of work is not large all accounting can usually be handled by two machines or even in some cases by one.

Many municipal departments use their customers' accounting machines to handle water, tax and assessment billing.

Mechanical Accounting for Small Units.—Some of you will contend that while it would pay large properties to adopt machine methods on their general accounting it would not work out so well on a smaller unit. The same question arose in the first pages of customers' accounting machine methods and yet it has proved worth while to both large and small utilities.

Accounting machines today are sufficiently flexible to permit of many classes of work being performed on one machine and it rests with each person to ascertain whether a thing can be done before they decide it cannot.

Now it is not to be deduced from this paper that machine methods are the only thing and that anyone who does not use machines for everything is behind the times. I am very much against the individual who walks into an office and immediately decides that everything is wrong and should be changed to his system. The reason possibly is that that individual knows only one system, and while the system may have worked well somewhere else, it may not fit at all well. In working out a system, one must look to the old-timers in an organization who know the business. What was done before was done to give them the information they wanted and there must have been a very good reason for adopting the method already in force or it would not be there. The axiom is, do not change a system unless the only way to improve it is to change it. If it is not working properly find out why.

How to Analyze Need for Machine.—Mr. W. H. Leffingwell in one of his books suggests that in making an examination of a system in force the following questions should be answered:

1. Is the work now being done satisfactorily? If not, why?
2. Is it due to some defect in the workers, or is it inherent in the operation?
3. In what particular form is it unsatisfactory?
4. Do the workers object to the work? If so, what is the objection? Is it a valid one?
5. What does the factor of time mean in this operation? Is it important to reduce the overall time?
6. What does it cost to do the work?
7. Can it be done more cheaply by hand by improving the operation?
8. What advantage is to be gained by having the work done by machine? Will it save labor, time or drudgery?

Having thus analyzed the need for a machine and having decided that a machine is necessary set about finding the proper machine for the job.

The foremost machine companies catering to the needs of public utility organizations have men specialized in every branch of public utility accounting and they will willingly make a survey of your work and submit their recommendations and proposals. Having received the proposals probably the best way to decide as to the merits of each is to ascertain from other utilities using similar equipment what their experience has been. If these users are willing to supply information on the following lines you will have something very definite to work on:

1. Production obtained.
2. Errors as per cent of items produced.
3. Speed and facility of paper handling.
4. Amount of investment.
5. Operating cost first year.
6. Operating cost following years.

So much for what machines will do in connection with Water Utility Accounting and how to select them, so now in conclusion let me enumerate a few DON'TS relative to machine methods:

1. Don't expect any system to work without proper supervision or planning.
2. Don't expect the machine to go around and collect the work, it can't do it. There must be a regular feed of work to the machine to get results.
3. Don't expect a machine to perform its allotted function under poor operation or improper handling. See that the operator really knows how to operate the machine.
4. Don't forget to have your machine serviced regularly.
5. Don't put a machine to work until the work is ready for the machine.

Acknowledgment.—The foregoing is an abstract of a paper presented at the St. Louis Convention of the American Water Works Association.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor

Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

With the British Sewage Works Operators: A Review of the 1929 Proceedings with Editorial Interpolations

THE Proceeding of the Association of Sewage Works Managers for 1929, just at hand offers a number of interesting parallels between the minds and work of the British workers in this field and their American cousins.

Research.—Right at the start off the report of the Honorable Examination and Research Secretary says, "Progress with regard to the research scheme has been somewhat disappointing although those members of the Association who are already imbued with the 'Research Spirit' have continued investigation of their respective problems, very little in the way of co-operation and collaboration has been achieved. The reason for this is difficult to explain. Is it that in connection with research in this country, there has always been a certain amount of feeling—a combination of jealousy and desire for secrecy—which seems difficult to eradicate?

"Has research become commercialized and are scientists losing their respect for the purely scientific and academic side of their profession in favor of the attractions of its commercial attractions? There is food for thought in these suggestions."

Yes, Cousin John, it is "that in connection with research in this country, there has always been a certain amount of feeling—a combination of jealousy and desire for secrecy—which seems difficult to eradicate," but you need not limit your statement to "this country." America has a bad case of the same disease. In fact that jealousy complex seems to be an integral part of the scientifically inclined mind.

The second part of your statement or question, "Has research become commercialized" can also be answered in the affirmative. And workers do favor the attractions of the commercial application rather than the scientific or academic side. We feel that this is inevitable and to a large extent as it should be, considering the source of funds for carrying on much of the research work and the fact that in no other way can the worker secure compensation for his labors. With this phase we are content but with the narrow minded jealousies that make scientific workers rush madly into print for fear some other worker will steal his thunder by announcing first that B-Whatisit is not a true Thingamagig but a para type, we have no patience whatever. Nor have we any patience with the pure scientist who goes out of his way to belittle the work of his fellows by heckling criticism, born of the aforementioned jealousy.

Such persons stand in the way of progress in the art and they will do so until someone finds a way to change human nature as applied to pure scientists.

Any apparent lack of cooperation among practical workers in the field of Sewage Disposal in America deserves an entirely different explanation which we believe will apply also to our English cousins. These men are willing and eager to give, to take and to exchange ideas. They are handicapped by lack of opportunity to exchange ideas and by the immense volume of routine work necessary to keep their plants in operation. Every contact with fellow workers seems to fill these men with good intentions along cooperative lines which intentions are subsequently lost sight of in the mass of detail required to make the local wheels go round smoothly and accomplish all, and in most cases a little more than, they were designed to accomplish.

The Chemist and Sewage Treatment.—Another writer. Mr. J. Herbert Spencer, in "Some General Thoughts on Sewage" refers to an anonymous contribution to "Surveyor" entitled "Foot Rule or Slide Rule" which he says "Rather over-accentuates the unnecessary and invidious, but all too prevalent distinctions between the theoretical and the practical man."

Mr. Spencer goes on as follows: "It seems, almost, that the ideal sewage specialist should have a prolonged general science and chemistry course followed by a few years devoted to biology and bacteriology and then an adequate training in engineering." "With such a grounding, he might, after a lifetime devoted to applying his accumulated knowledge to the special problems of sewage, claim to speak with authority on the subject." Since such training is impossible he suggests collaboration and points out that the great obstacle in the way of collaboration is the fact that each branch speaks a different language, a different technical jargon.

With the above introduction Mr. Spencer proceeds to describe sewage through the eyes of the chemist. He states that sewage treatment is very difficult because it is a process for removing last traces which is the most difficult thing in any chemical process. In so far as sewage treatment is a chemical reaction it would be an advantage to have a strong sewage to treat, because in accordance with the law of mass action the greater the concentration the faster the reaction. Not that a better effluent would result but that it would be easier to get a higher percentage removal. If one could treat a raw sewage containing 5 parts per 100,000 of 0 absorption value so as to give an effluent containing but 1 part, then a double concentration of the same sewage containing 10 parts in the raw, would yield not 2 parts in the effluent but say 1.8 owing to the more rapid reaction.

Since a stronger sewage suggests a smaller total flow, he reasons as follows: The result would be still further improved because, with the lower flow, the sewage would remain longer in the works.

"One practical conclusion from this reasoning is that it would be of advantage to exclude so far as possible purely diluting waters such as surface drainage—until after treatment. Suppose that in the example given above the increase in oxygen absorption from 5 to 10 parts is due to exclusion of such diluting water and that consequently an effluent is obtained with a figure of 1.6 instead of 1.0. If the diluting water be then admitted, AFTER purification, the liquid entering the river will have a figure of only 0.8."

For the Practical Operator.—Colloids, Spencer, defines as not any particular substance or class of substances but any substance too finely divided for simple physical separation and not sufficiently fine for rapid chemical treatment.

They are the bugbear of sewage disposal; at once the despair of the manager and the cause of his existence.

The following condensed statement from the lecture will be of value to the practical operator who has not the time to go deep into the theory of the matter: The particles remain in the colloidal state because they all have the same electrical charge either negative or positive. Hence they repel each other and remain separated. When any substance having opposite electrical charges is introduced into the suspension attraction results between opposite charges and the particles come together with resultant coagulation. With the particles coagulated into large groups they may be separated by gravity.

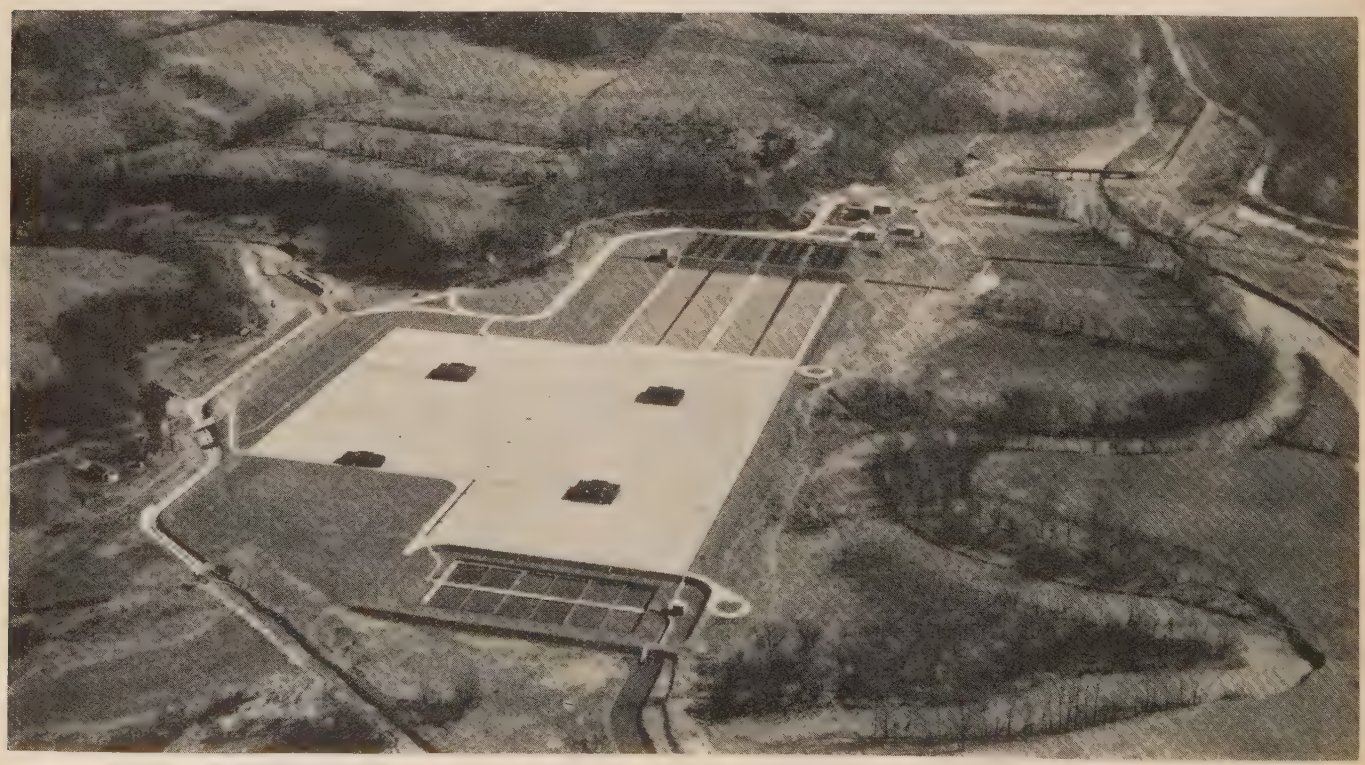
In a further attempt to bridge the gap between what the ideal works manager should know and what it is possible for him to gather in the short span of a single life Dr. Sciver has a short lecture on the elements of bacteriology and J. P. Todd on the principles of electrical measurements while W. S. Jackson, inspector for the West Riding Rivers Board for Sheffield and Rotherham gave an extensive paper on Stream Flows, Storm Water Overflows and Separating Weirs. The latter give principles of measurement and formulae with numerous diagrams for 3x D.W.F. and 6x D.W.F. He states that "These storm water overflows are a necessary evil on all combined sewerage systems and, in the writer's opinion, there is not yet a satisfactory design looked at from the point of view of rivers polution and the correct reduction of the flow to the purification works."

Successive Separation in Sewage Plants.—Mr. F. C. Temple, Chief Town Engineer, Jamshedpur, India presented a paper on *Successive Separation in Sewage Disposal Systems.*

While the discussion of this paper developed that some of his hearers characterized his work as dreaming and idealistic it seems to the reviewer that he has set down some very sound principles of sewage disposal which we might well take time to consider.

He says, "In all forms of (sewage) apparatus organic changes and separation both occur to a greater or less extent. Neither takes place without the other. From time to time in the history of scientific sewage disposal, there have been attempts to secure maximum organic change and maximum separation both together in the same tank" "The hope of the early experimenters of complete purification of sewage in one process was given up long ago—"

Speaking of two story tanks he says: "The great defect of these installations is that they try to do too much at one time in the same tank. The separation of solids and liquids is begun but is never completed, because the sludge is retained in the same tank for digestion. The products of digestion of the sludge, under these conditions, interfere with the separation and also interfere with other desirable action in the upper chambers. The more frequently the sludge is removed the better is the action and the clearer and more amenable to final treatment is the effluent passed on to the percolating filters. . . . The logical conclusion is that the lower chambers should only be made of such size as to contain that quantity of solids which will settle between



Sewage Treatment Plant, Akron, O. J. E. Root, Engineer of Sewerage. Metcalf & Eddy, Boston, Mass., Consulting Engineers

very frequent withdrawals of settled sludge to separate sludge digestion tanks."

"The ideal arrangement in a continuous flow tank and filter plant would be continuous removal of the solids from every part of the bottom of the tanks as fast as they are deposited."

"An essential feature of (the separate digestion) process is the separation of the liquids at the first possible moment in the settling tanks from the solids, with the minimum of liquifying action. It is the direct antithesis in this respect of the two-storied tank . . . At Birmingham elimination of the septic tank action eliminated also the coagulation of the solids in colloidal solution. The single settling action failed to separate (the colloids) and much other solid matter. The whole treatment of these solids, and the colloids, was thrown upon the percolating filters." It is in the coagulation and separation of these solids, according to Temple, that the bio-aeration, introduced between the settling tanks and the percolating filters at Birmingham and Croydon, was effective, though it was not originally introduced for this purpose, but as a complete treatment.

The ideal plant suggested by Temple would have 10 different separations between solids and liquids as follows:

I Grit Chamber; II Screen; III Preliminary settling in tanks 60 ft. long and two story design but with the lower chamber of very small proportions and arranged to be cleared almost continuously into digestion tanks; IV the sludge should be digested in plain tanks under gas collectors and the gas collected to be used for power to operate the plant. The digested sludge should be dried on beds, V, with possibly a preliminary dewatering treatment (Va). Proceeding with the liquid from III settling tanks, he proposes 4. Bio-Aeration; 5. Secondary Settling Tanks; 6. Sludge drying. 4a. Separation aeration and return of a portion of the A. sludge.

The reviewer believes that 6, drying of the excess activated sludge, will not normally be as simple as that, and that digestion of this sludge would form an additional separation (VI).

Bleaching Powder as an Auxiliary Treatment.—Mr. Herbert Bell, manager and chemist, Barnsley, considers the use of bleaching powder something more than a means of odor control as the result of his experience both at Barnsley and at Stratford-on-Avon.

He used bleach in 1911 at Stratford-on-Avon with excellent results applying three principles which he says were "rediscovered by our American friends in 1925." These principles were prechlorination, split chlorination and the advantages of treating fresh sewage. The latter he applied by cutting out the septic tanks and using a single tank for sedimentation only, and this tank was cleaned once a week. In an earlier attempt to control odors by the use of electrolitic chlorine the septic tank had been housed over as a further measure of odor control but this added to the H_2S content to such an extent that it absorbed all the chlorine without materially reducing the odors.

Bleach was added only when there was a positive reaction for H_2S in the air above a shaken sample and the dose of bleach was adjusted to a point at which this test was negative. The test for H_2S was the exposure of lead acetate paper above the shaken sample taking care that the test paper should not come into contact with any of the liquid.

He says "The deodorization appears to be more successful when the tank effluent can be maintained with a slight excess of free lime" and less bleach was required under such conditions. Economy was found in adding lime to save bleach. (Probably not true at present chlorine prices.)

At Barnsley it had been the practice to divert a portion of the flow from the bio-aeration tanks to certain trickling filters when the sewage was strong and septic. The cost of pumping the sewage to these filters was high and it was thought that the application of bleach ahead of the aeration unit would keep the sewage fresh and "Also encourage the aerobic organisms." The results of experiments along this line were so good that the method was adopted as standard practice.

Observing that while bleach prevented septic action it had no apparent inhibitive effect on oxidizing bacteria in trickling filters, Bell used bleach to "fortify" returned activated sludge which showed any sign of septicity with excellent results. From 18 to 30 P.P.M. of available Cl. was added to the returned sludge.

He also succeeded in bringing back to normal the bio-aeration tanks at times when they had been upset by sudden overloading, by the use of bleach and worked these tanks at considerable overload by the same means.

Bell also succeeded in using 1.65 grains per gallon of bleach in place of 2:75 grains of alumino-ferric as a precipitant at times when the sewage was so strong as to require a precipitant.

In his case, also, bleach was found to be effective in controlling the filter fly.

Cost Keeping for Sewage Disposal Works.—A costing system for sewage disposal works was presented by W. F. Freeborn, Cost Clerk, Manchester Corporation Rivers Department. The intricacies of the system outlined would delight the heart of any accountant but would drive an operator to the mad-house. It would be absolutely impossible to abstract this paper in an intelligible manner since it must be taken as a whole or not at all.

Fortunately the author had the grace to state that the system would require a separate costing department preferably at city headquarters.

The Epsom Plant.—Edward R. Capon describes the sewage works for the town of Epsom with a drainage area of 4,424 acres, a population of 26,500 and a D. W. Flow of 1¼ M. G. D.

In the present works are included broad irrigation, contact beds and Simplex surface aeration system of bio-aeration. The latter is the main point of interest at present as representing the climax of a long period of changes made in an attempt to keep up with the demands on the plant.

Septic tanks, contact beds, sludge lagoons and compressed air aeration tanks were among the things left in the discard by progressive development.

Preliminary settling tanks in advance of the aerators had, after considerable operating experience, been bypassed and finally turned into additional aerating units. Unsatisfactory experience with the "settling areas" in the aeration units had lead to the abandonment of this feature in favor of entirely separate settling tanks following the aerators. Finally instead of treating each aerator as a separate unit in parallel with the others, all of the sewage is now passed successively through each of the 12 aerating units in series and thence to the resettling tanks.

A 14 H. P. motor is provided for aeration and the power actually used is 11 H. P. (for 750,000 G. P. D.)

Sewage remains in the works for 14 hours and the 4-hour oxygen absorbed is reduced from 5.25 to 0.60.

Huddersfield Bio-Aeration Plant.—Huddersfield by the process of eliminating various methods of treatment which have not worked in the past has also arrived at bio-aeration as the coming method and has adopted the

Haworth paddlewheel system for an experimental plant of approximately 1 M. G. D. capacity.

This plant is described by W. D. Scouller.

The sewage consists of domestic waste 4 parts, textile wastes 3 parts and chemical wastes 2 parts. The chemical waste, however, dominates the situation having a 4-hour oxygen absorption value of 50 parts per 100,000 while the combined domestic and textile waste has a value of 20 parts. A large part of the chemical waste originating at a point near the works is separately piped and given preliminary treatment.

Effect of Iron Salts on Bio-Aeration.—Iron salts form a large part of the chemical waste and laboratory tests show that a small portion of iron helps purification but increased doses interfere with purification until at a concentration 10 parts per 100,000 purification stops. Gradual reduction of iron in the sewage leads to improved purification but abrupt cutting off the iron brings a drop in purification from which recovery is very slow.

A 13 per cent sludge was used and 30 H. P. was required per M. G. for aeration. This treatment resulted in a 4 hour oxygen absorption of 14-16 parts per 100,000.

Chingforf Sewerage and Sewage Disposal.—Mr. Martin states that Chingford covers an area of 2,807 acres and has population of 15,000. Early sewerage was on the combined system but more recent drainage was on the separate system. The works occupy a total area of 33¼ acres.

The plant consists of detritus tanks, screens primary and secondary sedimentation tanks and trickling filters, the latter are circular and fed by Simplex revolving distributers.

The 8 trickling filter units provide a total area of 45,000 sq. ft. and are 4 ft. deep which is considered ample for 20,000 persons.

The 4 primary settling tanks are 27 ft. in diameter and 27½ ft. deep having a combined capacity of 280,000 gal. and operate on the radial flow system.

The dry weather flow is 30 G. P. C. or a total of 450,000 gal. All flows above 3x D. W. are diverted.

Four sludge digestion tanks are 22 ft. in diameter and 21 ft. deep with a combined capacity of 32,000 cu. ft. (the figure of 66,812 cu. yd. given in the text is obviously in error). This allows 2.1 cu. ft. per capita on the present population and 1.6 cu. ft. per cap. on the 20,000 design basis. Gas is not collected though sealing rings are provided for installation of gas covers at a later date.

The effluent from the trickling filters is reported to contain 4 parts per 100,000 of nitric nitrogen uniformly.

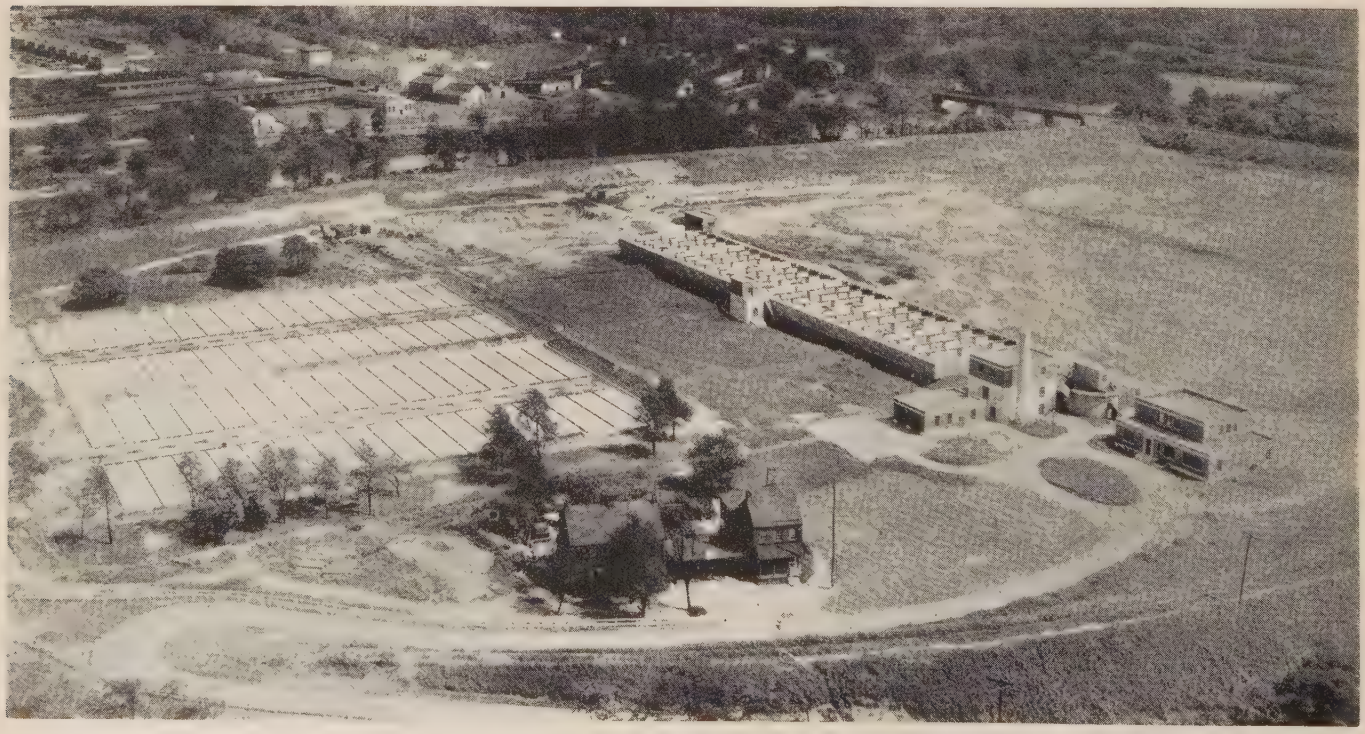
The Birmingham Plant.—Population 1,100,000; D. W. F. 33,000,000 gal. sedimentation tanks and bacteria beds.

A bioaeration plant for treating from 7.5 to 10 M. G. D. of sedimentation tank effluent is said to provide an effluent which can be applied to the bacteria beds at twice the rate formerly used. An additional 10 M. G. D. unit is in process of construction.

All sludge at the plant is digested and part of the digestion gases collected for power; 550 H. P. being recovered at the time (June, 1929).

▼

Water Consumption in New York City.—Figures for the first half of 1930, and including also the month of July, show the average daily consumption of water for New York City was 921,700,000 gals., or 65,700,000 ahead of the average daily consumption for the same period in 1929. Last year there were three very warm days in June when the consumption of water ran slightly over 1,000,000,000 gals., but this year an enormous increase in the use of water during the hot weather was shown for July and early in August, when the consumption ran over the billion mark every day, exclusive of Sundays, from July 18 through the first week in August. July 21 of this year set a record here for the amount of water consumed in one day, when 1,200,000,000 gals. were used. Several other days during the very hot spell ran more than 1,100,000,000 gals.



Sewage Treatment Plant of Allentown, Pa., Consisting of Imhoff Tanks and Sludge Drying Beds, with Provisions for Trickling Filters. Designed by Metcalf & Eddy, Consulting Engineers, Boston, Mass.

Zeolite Softening Plant of Sewickley, Penn.

A Description with Operating Results of One of the Pioneer Installations Using Zeolite in Gravity Type of Filter Unit

By D. E. DAVIS
Of The J. N. Chester Engineers, Pittsburgh, Pa.

ABOUT three years ago the first large municipal softening plant using Zeolite was built just below Pittsburgh, using four steel pressure units for enclosing the zeolite. In the design of the new plant at Sewickley, which is about twelve miles below Pittsburgh on the Ohio River, it was decided to employ the open gravity type of softening plant, quite similar in design to the usual gravity filtration plant.

The Raw Water Supply.—The raw water supply is a clear sparkling water which had been used for many years in the community without treatment of any kind, except chlorination. It is taken from a large timber crib which was built on the bottom of the Ohio River and covered over with sand gravel. The water is a true ground water and is as a rule about twice as hard as the river water immediately above. It is usually quite pure, and coli organisms are seldom in evidence. Its hardness averages about 200 p.p.m. of which about a third might be classed as permanent hardness. The water, therefore, might be regarded as offering a fine opportunity for softening with zeolite.

General Features of Plant.—The plant is located in a high class residential community, and special effort was made to give the building a pleasing appearance, since it faces a boulevard which will be heavily traveled. Viewed from the boulevard the building appears as a low brick structure trimmed in stone. The softening plant and laboratory occupying the portion on the right of the main entrance and lobby, and the office and pumping station that on the left. On entering the pumping station a visitor would see a round railing at the top of a deep watertight concrete well. Looking over this railing he would see a spiral stairway around the walls of the circular pit, leading to the floor about 41 ft. below, on which are mounted to motor driven centrifugal pumps (each of 1,400 g.p.m. capacity). These pumps lift the water from the river crib through a pipe line laid in a concrete tunnel and deliver it into a small basin just outside the plant.

On the pump room floor, on which the railing is erected, there are duplicate motor driven pumps, which take the final softened water and pump it to the storage reservoirs on the hills above the borough. There is also a wash pump for back-flushing the softening beds. A hand crane runs over this part of the station and is of considerable help in handling heavy material.

Details of Softening Plant.—The heart of the softening plant is at the other end of the building opposite the pump station and consists of four rectangular concrete beds which have very much the same appearance as the usual type of gravity filter units. In fact, with some modifications, that is exactly what they are. One of the beds contains ordinary filter sand, while the other three beds are equipped with green sand (or zeolite) which is used for softening. If the visitor looked over into one of these beds he would see the clear hard water as it came from the small equalizing basin outside. A few inches below the surface he would see two steel filter troughs running the length of the bed and below that again the sand above mentioned. There is 30 in. of this sand below that 18 in. of graded gravel, the bottom and coarsest part of which is placed immediately around and over the bronze strainers of the umbrella type which perforate the softener bottom on 6 in. centers. Immediately in front of each softener there is a marble table on which are mounted the handles for operating the hydraulic valves controlling the softener units, as well as the gauges, which give a picture of the operating conditions in the softening units.

If the visitor stepped outside the plant he would see a rectangular concrete basin about 16 ft. deep whose top is nearly level with the ground. Looking over the iron railing he would see a clear water (really a saturated brine) with possibly a carload of ordinary granulated salt appearing at the bottom of the tank trough the brine solution. This tank is large enough to hold two carloads of salt. The salt is hauled by dump trucks which simply back up to this basin and dump their load directly into the brine solution. It is an extremely simple and effective storage arrangement, being compact and lending itself to ease of handling. Naturally the salt solution does not freeze.

How the Process Works.—The softening medium is a green sand (called glauconite) which is found in natural state and in very large quantities near the New Jersey coast line. It is washed, sized and treated so that on arriving it is fairly uniform in size (coefficient 1.50) and fairly fine (about .29 mm. effective size), or a little finer than the usual filter sand.

In the case of the Sewickley plant the water passes down through the sand bed and is softened in three of the units whereas in the fourth unit is is merely filtered through. The soft water from the three units is mixed with the hard water from the fourth unit so that the final product has about 65 p.p.m. of hardness remaining, which is regarded as being quite satisfactory since it is less than one-third as hard on the average as the crib water.

The sodium in the green sand is used up after a certain amount of water has passed through the bed and it is then necessary to renew or "regenerate" it. In doing this a definite amount of saturated salt brine is drawn into a concrete chamber in the basement, and then diluted to about a 5 per cent solution. When the operator is ready to regenerate the bed, he pushes a button on the control table, beside the softener, to start up a small centrifugal pump which delivers the brine through perforated pipes over the entire surface of the bed. A small valve is then opened and the brine solution is drawn slowly down through the sand. There is another "switch of partners" and the sodium in the salt now goes into the green sand and the calcium and magnesium is washed out of the bed to the sewer, by passing clear hard water through the bed until the waste material has been removed. The bed is then ready to start all over again, and from all indications there is no wearing out of the sand and the cycle can be continued "forever and two days."

Operating Results.—Since the plant began its operation in February of 1929 up to the end of May, 1930,

its has delivered 424,530,000 gal. of water. The average hardness of the water has been 195.4 p.p.m., and the final product has averaged 65.4 p.p.m. This represents a removal of 130 p.p.m. of hardness, in the doing of which a total of 664 tons of salt have been used; or at the rate of .39 lb. of salt per thousand grains of hardness removed, which may be regarded as a low figure. Tests extending over several months indicate that the sand has a capacity of removing approximately 3900 grains of hardness per cubic foot of the mineral which is also a good performance. This is largely accounted for by the fact that the operating rate and the vertical flow through a constant rectangular cross-section make it possible for every sand grain to work to the maximum efficiency.

The thing which strikes a visitor forcibly is the extreme simplicity of the operation. The entire plant is run by one man per shift, who has ample time to attend to all details without being rushed. The areas of the sand bed and the rate of flow, etc., are held the same as in a filtration plant. This was done with intention, so that if any break should occur in the timber crib, admitting river water, the plant could be converted into a filtration plant within an hour's notice by simply adding alum through the dry feed machine provided for that purpose. Definite schedules are followed, such that the beds are regenerated alternately.

Data on Plant Operation

Date	Pumpage in Mil. Total	Gals. Ave. Daily	Gals. of Wash Water	No. Regen.	Hardness in p.p. m. Raw	Hardness in p.p. m. Final	Approx. Salt in Pounds	Hardness Removed in gr. Per Gal.	Lbs. of Salt per 1000 gr. Removed
1929									
Feb. 13									
Feb. 28	13.22	.825	440,000	68	219	80.8	42,700	8.09	.398
Mar. 31	21.96	.708	260,000	93	184.8	64.8	58,400	7.02	.380
Apr. 30	22.49	.749	220,000	88	165	58.3	55,300	6.23	.396
May 31	22.10	.714	140,000	80	172	61.2	50,200	6.47	.351
June 30	33.35	1.111	120,000	166	209.6	61.1	104,200	8.68	.361
July 31	31.81	1.026	180,000	171	224.4	63.0	107,300	9.44	.357
Aug. 31	35.72	1.151	220,000	204	242	72.7	128,100	9.90	.362
Sept. 30	30.06	1.002	240,000	189	272.5	97.5	118,800	10.24	.386
Oct. 31	25.16	.811	200,000	161	238.0	62.8	101,100	10.25	.394
Nov. 30	29.01	.968	200,000	121	177.3	61.4	76,100	6.77	.388
Dec. 31	27.43	.886	100,000	116	169.5	62.2	72,700	6.28	.422
1930									
Jan. 31	26.79	.864	120,000	97	159	62.9	69,900	5.62	.406
Feb. 28	24.95	.892	120,000	103	172	62.8	64,500	6.39	.405
Mar. 31	29.75	.958	220,000	117	168.3	62.5	73,300	6.18	.399
Apr. 30	22.91	.764	140,000	88	170.2	60.1	55,300	6.44	.376
May 31	27.82	.898	200,000	135	192	60.6	84,500	7.68	.395
				1997					
Total	424.53		3,120,000	2,800,000			1,253,400		
Ave. 473 days	.898	.898	6,600	1,440	195.4	65.4		7.6	.389

Estimated Distribution of Low Service Pumpage

	Pumpage	Per cent
Rinsing—approx.	31,100,000	6.7
Wash Water	3,120,000	.67
Brine	2,880,000	.62
Pumpage, high service	424,530,000	92.
Estimated low service pumpage	461,630,000	100.00

Unit Costs

Power—per million gallons	$19.20
Wages—per million gallons	11.40
Salt and Hauling	9.85

Acknowledgement.—The foregoing is a paper presented before the Pennsylvania Section of the American Water Works Association.

Model Sewage Works for Mississippi State Sanatorium

Plans and specifications have been prepared for a new sewage treatment plant for the Mississippi State Tuberculosis Sanatorium at Sanatorium, Miss. The sanatorium is under the supervision of the Mississippi State Board of Health, and the Bureau of Sanitary Engineering prepared the plans and specifications and will have charge of the installation.

The present treatment plant consists of a small septic tank and three small sand filters now greatly outgrown. The new plant will consist of a pumping station with duplicate pump installation, Imhoff tank, twin dosing tank for common nozzle field trickling filter, and resedimentation tank. Chlorinators will be provided to chlorinate raw sewage entering the pump pit and the filter effluent entering the resedimentation tank. Discharge will be into a small running creek. The existing septic tank will be utilized as the resedimentation tank and the existing sand filters will be converted into sludge drying beds.

The present normal dry-weather flow of sewage amounts to 200 g.p.m.; the maximum hourly flow is 313 g.p.m. The plan is designed for a 16 per cent increase over the present flow. The cost will be approximately $35,000.

It is intended to make this a model plant and equip it to serve as an experimental ground for the Bureau of Sanitary Engineering and a demonstration to municipal officials confronted with sewage treatment problems who might be interested in this type of plant.

Water Consumption Records Broken in St. Louis.—All records for water consumption in St. Louis during a single month were broken during the heat-ridden July. During the 31 days, on many of which the mercury soared over 100, the city water department pumped 5,052,651,910 gals. of water. This is an increase of 726,722,630 gals., or approximately 17 per cent, over last year, when 4,325,929,280 gals. were pumped.

Laboratory Control of Filter Plants

The Problems of the Purification of a Water Supply for Thousands of People Are Complex and Cannot Be Solved in a Rule-of-Thumb Manner

By A. C. JANZIG

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WHEN no preliminary analytical survey of the raw water is conducted before the plant is put into operation, the first concern of the plant operator is to ascertain the bacterial and chemical characteristics of the raw water employed.

Some of the questions which will naturally arise are: What are the physical and chemical constituents of the water? What is the bacterial load of raw water, and are there large numbers of the B. coli group present? What is the biological nature of the water to be treated?

Each Supply a Separate Study.—Contrary to popular belief, not all raw waters have the same characteristics and will not respond to the same treatment, but each raw water supply becomes a separate study in itself. For instance, there are certain highly colored waters which will yield to coagulation and color removal with alum, while for other waters it has been found more effective to use lime and iron, chlorinated copperas, or sodium aluminate as coagulants. By experimentation with color reduction tests and alkalinity and hydrogen-ion determination, the water analyst soon recognizes the most efficient coagulant to use. The economic control in the use of coagulants is seen to be a very important item when one considers the large sums of money spent annually for the removal of color and turbidity.

Frequent color readings are important, as the slightest change, i. e., one part per million or more of color, can be detected by the trained analyst. This apparently trifle change in color may make a difference in chemical treatment of from $5.00 to $10.00 per day where large volumes of water are treated. Armstrong (1) at Omaha, Neb., reported that laboratory supervision saved the city $9,000 per year.

Color Removal.—Where the color is to be removed from a raw water, the intensity and the time in mixing the coagulants are important factors. Laboratory experiments have pointed out that at certain seasons of the year a lengthy mix of chemicals may be detrimental to good "floc" formation. As an example of this point, it was found by laboratory observations at one of the Minneapolis filter plants that a better color removal could be obtained if several baffles were removed from the mixing chamber. In this particular case, determinations of color, "floc" formation, and rate of settling were used as guides in establishing the proper amount of mixing required.

Another point of importance is the detention period in which the water is allowed to remain in the coagulating basins. The laboratory is again called upon to say whether a minimum of 2 or a maximum of 5 hours of contact is desired, so that an economy of coagulant may result. Valuable detention period data can be secured by making observations of "floc" formation and the rate of settling of suspended matter at different points in the coagulating basin.

In some cases poor coagulation, as determined by color removal and bacterial reduction, may be caused by an over as well as an under dose of coagulant. The control of coagulation at the optimum point results in a better filter effluent, as well as a maximum efficiency with a minimum amount of chemicals. For checking the amount of applied alum to a coagulated water, the alkalinity determinations are valuable tests, as the alkalinity reduction is proportional to the amount of alum added. The introduction of hydrogen-ion determinations has made it possible to control the pH (acid and alkaline character) of a water, so that the chemical reactions will go to completion.

Study Required of Individual Filter Units.—The individual filter units will require study so that they will produce an effluent of low bacterial count and free from suspended matter. Routine samples taken from the effluents of each filter unit and tested for the presence of turbidity and color will, in some instances, furnish a better guide for washing filters than the customary dependence on "loss-of-head." A fruitful field for research may be found in determining the physical and bacterial loads permissible for rapid sand filters. A periodic examination of the filter sand will indicate the "effective size" and the nature of the material adhering to the surface of the sand grains. The coatings of some sand grains have been found by chemical analysis to consist of insoluble manganese, which in this condition would be of no consequence; but when conditions become favorable, as occurred at the Columbia Heights filtration plant (2), this element redissolves and becomes a problem. In this case some of the idle filters which were again put into service delivered a high percentage of soluble manganese, extending in some instances for two to three days.

Producing Non-Corrosive Water.—Another important problem from the standpoint of boiler-water is the production of a non-corrosive water. In many cases it is necessary to decrease the hydrogen-ion concentration after filtration by treating the water with lime, soda ash, or some other alkali. By making pH determinations and by titrating for the carbon dioxide content, one can regulate the reaction of the water to the point where the smallest amount of corrosion will take place with a minimum dosage of alkali. Dissolved oxygen determinations of a water will in many cases indicate whether the oxygen concentration is a factor in the process of corrosion. An example of what can be done with a corrosive water is reported by Williams (3) of the West Palm Beach Water Company where "red water" trouble was remedied by a careful chemical control. He found that a water having a carbon dioxide content varying between 2 and 6 parts per million and with a pH between 6.2 and 6.8 was sufficient to cause severe corrosion in the distribution system. The presence of 9 parts per million of dissolved oxygen rendered this carbon dioxide highly aggressive.

In cases where the total hardness of a water is exceptionally high, filter plants are equipped to soften as well as purify the water supply. The removal of calcium and magnesium eliminates soap waste and boiler scale and in many cases leaves the water in a non-corrosive condition. Routine hardness, alkalinity, and hydrogen-ion tests will give the operating data neces-

sary to carry the softening process to an efficient completion and to maintain the proper chemical balance.

Taste and Odor Removal.—The production of a water free from tastes and odors has become a perplexing problem for some filter plants. The disappearance of dissolved oxygen in a raw water and the presence of large quantities of organic matter and traces of phenol compounds are indicative of approaching trouble. To remedy a condition of this kind intensive laboratory research must be carried out by testing the effectiveness of methods such as aeration, excess lime treatment, prechlorination, ammonia-chlorine treatment, and filtration with activated carbon.

The final treatment of a coagulated and filtered water, which is sometimes referred to as sterilization, is accomplished in most plants by the use of chlorine. The proper chlorine dosage is determined by correlating data of the chlorine capacity of the water and by residual chlorine tests and bacteriological examinations. The chlorine consuming power of waters varies greatly, so that this phase of the purification process requires intensive study.

The safe-guarding of a water-supply can be accomplished intelligently only by routine bacteriological analyses. The organisms belonging to the B. coli-aerogenes group are the recognized indices of pollution and their determination should be standard practice at all filter plants. This is the only practical means known to sanitary science by which the possible presence of water-borne disease-producing organisms can be indicated.

Therefore in conclusion, the control of a filter plant should include physical and chemical determinations, qualitative and quantitative bacterial examinations and periodic plankton counts. By these routine tests applied through the various stages in the purification process, a filter plant will be placed on an efficient operating basis. The purification of a water-supply for thousands of people cannot be effected by a rule-of-thumb manner, as the problems are complex and it is desirable to obtain the utmost in economy and efficiency.

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(2) Janzig and Montank: High manganese effluents from idle filters. Jour. Amer. Water Works Assoc., Oct., 1929, pp. 1319-28.

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New Automatic Equipment Speeds Water Service

A new piece of automotive equipment which speeds up service more than 75 per cent in some classes of maintenance work and is proving its merit especially as a one-man emergency machine has been developed by the Hackensack Water Co., Weehawken, N. J.

The equipment, attached to a 1¼-ton truck, has been under test for the last 14 months in the company's daily work. It has been assembled by George F. Weighardt, hydraulic engineer in charge of distribution over the 800 miles of mains in the company's system. It consists of pumps, gears for opening and closing main valves, and emergency appliances, and is actually a composite of several pieces of service machinery required in water utility work.

The truck in some respects resembles a police patrol car. Attached to the running board on the left side, and connected with the motor, is a gear which can be fitted in a few minutes to main valves which require opening or closing. Under the front end of the radiator is a hose connection attached to a pump which is also operated by the motor.

Opening or closing large valves is ordinarily one of the most laborious operations which a water company crew encounters, A 36-in. valve requires about 250 turns and under the usual system a crew of six or eight men, grasping a bar locked to the top of the valve, walk around in a circle. The whole operation of opening and closing one of these valves formerly occupied from three to four hours exclusive of any repair work.

When a valve job now occurs in any part of the company's system, the new truck is dispatched with a crew of two men. The gear on the running board is brought over the valve, dropped and locked to it. The driver then starts the motor and the number of turns imparted to the valve appears on a gauge set in the instrument board. Even working at slow speed, the truck mechanism can open or close a 3-ft. valve in 30 minutes and with less strain on the metal.

The pump attached to the motor is equally efficient. Confronted with a flooded excavation or manhole, the truck crew attach a section of hose to the pump connection and start the motor. A pull of 300 gal. per minute can be exerted by the truck's engine. A large portable searchlight makes it possible for the truck crew to work under any conditions of darkness.

Enclosed in boxes mounted on the sides of the truck are extra hose sections, tools, repair parts and clothing for crews. Even a full set of maps showing the location of every valve in the company system is part of the equipment, making unnecessary any reference to office records, even by telephone.

When loaded with its maximum complement of tools and emergency materials, the new truck weighs about 3 tons. Standard crew is three men and a driver, but every operation can be performed by the driver and one man.

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New York City Has City Planning Department

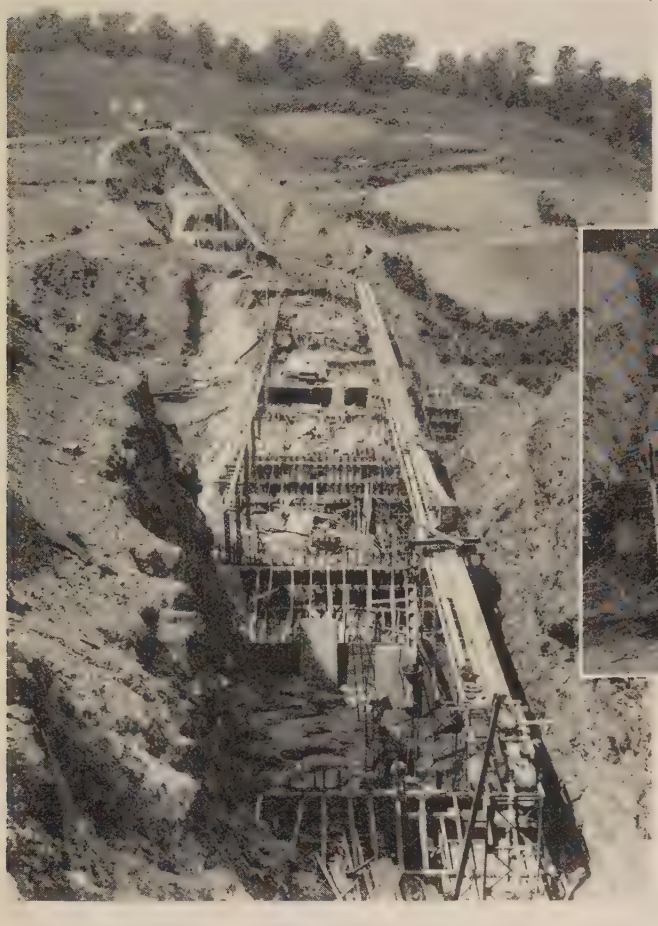
New York City now has a Department of City Planning, the law creating this department becoming effective on Sept. 1. Major John F. Sullivan has been appointed the City Planning Commissioner, He will construct a topographical model of the city which will show existing and authorized streets, highways, street grades, public places, bridges and tunnels, and in fact all the other features of the physical make-up of the city. He will also prepare a master plan of the city, which, in addition to showing the existing physical status, will also serve as a guide or central plan for future city improvements. The Department of City Planning is to act as a co-ordinating agency for projects under consideration by the various city departments. The commissioner can recommend, but cannot force the adoption of his suggestions or decisions. His powers are only advisory. He will, however, make preliminary recommendations on all plans or projects for major improvements relating to or affecting the master plan previous to their presentation to the Board of Estimate and Apportionment. He will also report on proposed changes in the present map or plan of the city.

The Belt Conveyor in Dam Construction

The Central Mixing Plant and Conveyor No. 1

AN interesting layout of belt conveyors in being employed in the construction of the Old Mill Stream Dam of the additional water supply development of the City of Wilmington, Del. The gravity section type concrete dam will be approximately 1000 ft. across the crest with a base thickness of about 90 ft. and a thickness at crest of 16 ft.

The concrete is mixed in a central mixing plant and spread on conveyor No. 1—a 24-in. belt running up the side hill at an angle of approximately 15° and for a distance of about 850 ft. The concrete is transferred to conveyer No. 2 which carries it for a distance of about 360 ft. It is then transferred to conveyor No. 3 which continues across the dam. In the lower part of the valley, where the dam has the greatest crosssectional area, the concrete is transferred to a belt on a gantry crane, and is placed by counter-balanced chutes.



Junction of Conveyors No. 1 and No. 2 and No. 3 Tank

Conveyor No. 3, Gantry Crane and Placing Chutes

Upstream Face of Dam on Sept. 4. Some 70 ft. in Height Was to Be Added

Necessary Tests at Small Filtration Plants

Simple Tests That Can Be Run by the Smallest Plant and the Inexperienced Operator Who Has Little or No Chemical Training

By J. M. JESTER

Assistant Engineer, Washington Suburban Sanitary District, Hyattsville, Md.

OPERATORS of small water filtration plants frefrequently fail to recognize the importance of making certain daily tests as well as recording their results. Some may consider these tests too difficult, while others may not run them for lack of interest. As a rule, the necessary tests may be run at the small filtration plant without a great deal of effort. A copy of "Water Purification Plants and Their Operation," by Stein, and "Standard Methods of Water Analysis," by the American Public Health Association, will be found helpful to the operator.

The water supplied a community should be safe from a bacteriological standpoint and of acceptable physical quality. These requirements can be effected only through the frequent running of routine tests. The results of the tests, if recorded, will be valuable in establishing the purity of a water for weeks previously, in the event of a typhoid epidemic, as well as an aid in eliminating many operating difficulties. A comparison of records from time to time will help in obtaining better plant efficiency, and if the records are placed in the proper authorities' hands they may aid operators of other plants, should they have difficulty with unusual operating conditions.

Sampling.—In order to obtain accurate results from tests, care should be taken in the collection of samples for testing. Carelessness in gathering specimens is not only a waste of time, but misleading in the results obtained. When taking samples for chemical analysis, glass stoppered bottles free from alkalies and acids should be used. The bottles should be rinsed several times in the water to be tested before actually collecting the specimens. When taking a sample from a stream, the bottle should be filled by a slow motion away from the body, in order to prevent the water from coming in contact with the hand before entering the bottle.

Turbidity.—Next to the proper sterilization of a water supply, the elimination of turbidity is of prime importance. The efficiency of the whole filtration process depends largely upon the continuous removal of turbidity from the raw water. The operator of a filtration plant should know at all times both the degree and character of the turbidity in the raw water entering the plant and the completeness of turbidity removal in the filtered water. Turbidity, as to character, is gauged by its coarseness or fineness. This condition will depend to a large extent upon the geological nature of the water-shed. A knowledge of the raw water turbidity is necessary at all times in order to determine the proper amounts of coagulants to be applied. When difficulty is experienced in obtaining a satisfactory floc with a fine turbidity or after a sudden thaw, jar tests will be found to be of much practical value in determining the amount and combination of coagulants to obtain the best floc. I recall several years ago when difficulty was experienced in treating a raw water with a turbidity of several hundred p.p.m., following a sudden thaw, a sample of the water was taken and a jar test run. Very little floc was obtained with a straight alum treatment, regardless of the dosage. A better floc was obtained by the addition of soda ash, and a satisfactory floc by the combination of alum, lime and soda ash. The proper dosage known, this combination was applied on a plant scale with satisfactory effluents resulting. Jar tests require but little time and the results obtained, both in satisfactory effluents and a probable saving in chemicals, are well worth the effort.

While a high raw water turbidity does not always indicate a high state of pollution and filter effluents having a turbidity of 5 p.p.m. or thereabouts may not cause complaint from the consumer, the lower the effluent turbidity is kept, the lower the residual chlorine may be dropped to insure sterile water.

For the reading of turbidities ranging from 5 to 100 p.p.m., the bottle type turbidity standard is generally used, while with turbidities above 100 p.p.m. the candle type tubidimeter is more satisfactory. With the bottle type standards, the bottle used for collecting the samples should be of the same make as those which contain the standard solutions. If the operator permits this bottle to become coated on the inside, incorrect readings will result, especially with turbidities ranging between 50 and 100 p.p.m. With the candle type turbidimeter care should be taken to keep the flat bottom of the graduated tube free from sediment.

In determining the turbidity of effluents, the Baylis type turbidimeter is recommended. This turbidimeter has a range of 0.1 to 2 p.p.m. and will aid materially in keeping the turbidity of the effluents at a minimum. Prior to the use of this type of turbidimeter at the Burnt Mills Station of the Washington Suburban Sanitary District, a residual chlorine figure of 0.28 to 0.35 p.p.m. was necessary for satisfactory bacterial results, but since its use better effluents have been maintained and satisfactory results obtained with residual chlorine ranging from 0.14 to 0.35 p.p.m.

Hydrogen-ion Concentration.—Hydrogen-ion concentration, more frequently termed pH, is based upon the magnetic attraction of positively and negatively charged ions of which the water is composed, and is used to determine to what degree a water is acid or alkaline.

There are several methods which may be employed to determine the various pH values of water, but for general purposes the colorimetric method seems the most satisfactory. This method employs the use of a standard color indicator and a set of color standards. The color of the indicator to be used, as well as the range of the color standards, depends upon the acidity or alkalinity of the water to be tested. Color standards should be kept in a dark place, when not in use and away from the sunlight as much as possible, to prevent fading. The standards should be checked for accuracy at least once a year.

In making pH determinations the hands should be clean and free from acids or alkalies, as a very small amount of either coming in contact with the water to be tested will result in incorrect readings.

Hydrogen-ion determinations, both in the raw and filtered water, are highly important in the daily opera-

tion of the filtration plant. Waters have varying degrees of acidity or alkalinity, and a maximum precipitation of impurities will take place at a certain pH, which is termed the optimum point. The optimum point for a given water may be obtained by running a series of jar tests with various turbidities and under differing operating conditions. A curve plotted from the results of these tests will aid materially in obtaining satisfactory coagulation during unusual operating conditions. Should the pH value of the raw water be below the optimum point, alkalies are added in obtaining a good floc, or should the reading be higher than the optimum point, more alum is required where alum is used for a coagulant. The pH control on raw water will prove exceedingly helpful in controlling chemical dosages and obtaining satisfactory coagulation.

Alkaline water is highly desirable in the distribution system, as acid waters are likely to cause complaint and criticism. The most frequent complaint heard is that of red water. This is due to an acid water attacking the plumbing and the reaction which takes place when the acid water is heated in the hot water tank. There is no doubt in the writer's mind but that red water troubles could be practically eliminated if the proper pH in the filtered water were maintained at the filtration plant. Aside from red water troubles, an acid water will cause galvanized piping in house connections and plumbing to corrode to such an extent that it may have to be completely renewed in a comparatively short time. Also, the carrying capacity of the water mains will decrease.

As previously stated, an alkaline water is desirable but it should be borne in mind that if the pH value be kept too high the water will be hard and not palatable, which may also result in complaints. Hourly determination of filtered water pH will result in water of uniform alkalinity being delivered the consumer.

Hardness.—Hardness, usually caused by calcium and magnesia, is expressed in terms of calcium carbonate. The calcium carbonate equivalent of calcium and magnesium content, sometimes with iron and aluminum, is a measure of total hardness in a water. The soap method of determining total hardness, though giving only approximate results, is usually satisfactory for the small plant. With this method a standard soap solution is used to titrate 50 c.c. of the sample in a 250 c.c. glass-stoppered bottle until a permanent lather is obtained. The amount of soap solution required being known, the total hardness in p.p.m. may be found by referring to Table No. 5 in "Standard Methods of Water Analysis."

The amount of total hardness a water may have, without causing complaint regarding taste and suitability for washing purposes, depends upon the locality being served. Some communities are supplied a water having a total hardness of 100 or 200 p.p.m. There is no complaint because the populace is accustomed to a hard water. However, a water having a total hardness of not more than from 25 to 35 p.p.m. is desirable.

Hard water is objectionable to large consumers using tubular boilers, due to the incrustation which forms on the boiler tubes, causing a higher fuel consumption and the necessity of more frequent cleaning of the tubes.

Tests for total hardness should be made on the raw water and filtered water at least once each day.

Residual Chlorine.—Tests for residual chlorine should be frequent enough for the operator to know at all times the amount present in the filtered water. The most usual method for determining residual chlorine is with ortho-tolidine. This method consists of a standard ortho-tolidine solution with permanent color standards. For the small plant it is most convenient and accurate to buy this type of outfit from a reliable firm selling such supplies.

The amount of available chlorine required to sterilize a water depends upon the amount of organic matter present in the water. The lower the effluent turbidity and the lower the amount of organic matter present, the smaller quantity of chlorine needed for sterilization. As fluctuations in water temperature, organic matter and water delivery affect the amount of chlorine required, it is advisable to make a residual test once each hour or so. In this way accurate control may be maintained. Should the effluents become turbid, bacteriological results show positive, or any other unusual conditions occur, however, the chlorine dose should be immediately increased sufficiently to take care of the existing condition.

It is desirable to run the residual chlorine as low as possible, consistent with safety, because of its tendency to aggravate and produce objectionable tastes and odors. Popular complaint on this score, though annoying, is of secondary importance to sterility.

Taste and Odors.—The waters from most streams, suitable for use as sources of public water supply, do not possess, under ordinary conditions, seriously objectionable tastes or odors, except where there are industrial plants emptying wastes above the supply intake. There are periods, however, when tastes and odors in the waters of streams, generally speaking, are objectionable. These are usually after a heavy rain or thaw. The frequent testing for tastes and odors will result in a quicker detection of objectionable conditions, and if their removal is possible and prompt, this action may save considerable criticism from consumers.

For testing odors in cold water, approximately 250 c.c. of the samples are placed in a 500 c.c. bottle and shaken well. The bottle is then allowed to stand until the water has reached approximately the temperature of the room, whereupon the stopper is removed and the odor noted. For testing odors in hot water, approximately 150 c.c. of the samples are placed in a 500 c.c. Erlenmyer flask, covered with a tight fitting watch glass, and heated. Just before the boiling point is reached, the water is agitated by a revolving motion of the flask, the watch glass removed, and the odor noted.

A comparison of the results obtained from these tests following turbidity changes, thaws, etc., may be of much value in determining the cause of certain objectionable tastes and odors. The results of taste and odor should be recorded to agree with the designations for quality and strength given by the "Standard Methods of Water Analysis."

Conclusion.—The above mentioned determinations can be made by any operator if he is interested in the proper control of his plant. Frequent observations are necessary if the results are to be of real value. Such procedure will give the operator a better understanding of the principles involved in water purification, the causes of operating troubles, and the methods to be employed in eliminating such difficulties.

Acknowledgment—The foregoing is a paper presented at the 4th annual conference of the Maryland Water and Sewerage Association.

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WATER WORKS PAY ALL CITY EXPENSES.—For the third successive year the city council of Colby, Kan., voted to let the municipal water plant pay the city's bills. During two years earnings of the plant has paid administration bills, provided for pavements, paid for new equipment and placed a balance of $45,000 in the city treasury.

The Reforestation of Public Water Supply Watersheds

The Developments in Eastern States and a Discussion of the Parallel Uses Which Are Being Made of Watersheds Aside from the Protection and Improvement of Water Supply, Including Such Possibilities as Practice of Forestry, Landscape Improvement and Recreational Use

By JAMES O. HAZARD
Assistant Forester, Virginia Forest Service

THE reforestation of open lands on public water supply watersheds is of quite recent development in this country. A few notable beginnings were made as much as 30 years ago, substantial increases are recorded as of 20 years ago, but the most extensive plantings are of the past 10 years. It is difficult to say whether this development has come as a result of the increase in public interest in reforestation or as a result of the ever increasing demands of our communities for that high type of water supply which can usually be secured best from properly managed forested catchment areas. It is noteworthy that increase in watershed reforestation closely parallels the increase in the educational and direct service activities of our state forestry departments. Some water companies have doubtless been interested in reforesting their watersheds from the point of view of putting idle lands into use, but it is certain that many water companies have been obliged to reforest parts of their catchment areas, particularly those adjacent to their streams and reservoirs, in order to prevent the harmful silting up of the same. While grass sod will prevent soil erosion in some cases, it is more expensive to maintain than forest cover and is less effective under average conditions.

Benefit of Forest Covers for Watersheds.—Common human experience in observing the performance of springs, streams and lakes, with and without protective forest cover, and scientific data secured by painstaking experiment and research, agree that forest cover provides the best type of protection to watersheds. It has been scientifically proven by studies made in Europe and America that forests

(a) Increase local precipitation;
(b) Stabilize the flows of springs and streams;
(c) Decrease the waste of water through excessive run-off such as usually occurs in their absence;
(d) Temper the climate;
(e) Effectively prevent erosion with its accompanying costly waste of soil and silting of streams and reservoirs.

All of these beneficial influences become active as soon as a forest cover is established and remain so until it is destroyed. In the planting of forests it has been found that many species will provide a complete ground cover in from seven to ten years. While the beneficial effects of a young forest are not as great as those of a mature forest, substantial benefits to watersheds have been noted from planted forests not more than ten years old.

What Has Been Accomplished in Watershed Reforestation.—The fact that forest cover for watersheds is regarded as ideal by both scientists and laymen is probably responsible for the substantial progress that has been made in recent years in the reforestation of the open lands of many important public water supply watersheds. To give you some indication of the extent of the watershed reforestation that has been accomplished within the past 30 years, I will summarize such information as I have, covering this activity in a number of our eastern states. This information has been obtained in part from state forestry departments and in part from water companies themselves.

In Massachusetts, 2,663,000 trees have been planted in 86 town forests, nineteen of which are used as watersheds.

In Connecticut, 20 cities and towns or other political districts own watershed protection forests having a total area of approximately 23,000 acres, 13,000 acres of which is more or less wooded naturally and 1,000 acres of which have been reforested by the planting of approximately 1,200,000 trees. Three private water companies owning about 40,000 acres have planted about 4,357,000 trees.

In New York State two-thirds of the cities have planted forests around their sources of water supply. Twelve of these have planted 10,224,400 trees, mostly on watersheds. In many cases this reforestation is a result of programs extending over a period of from 15 to 30 years.

In New Jersey, 15 municipalities and private water companies are actively reforesting their watersheds.

In Pennsylvania the Department of Forests and Waters makes the following statement which is indicative of the situation within that state. "Since 1910 . . . 122 water companies have planted a total of 10,000,000 trees (secured from the state nurseries) on their watersheds. Several million additional trees purchased from private nurseries were also planted. Pennsylvania's reforestation program is a very helpful factor in conserving supplies of potable waters needed by the people and the industries of the state."

These brief statements clearly indicate that forest cover is rapidly being provided for watershed protection purposes throughout the northeastern states. Additional correspondence which I have had with many of these water companies indicates that a large majority of them definitely plan to completely reforest all idle open areas within their watersheds. Among those who are committed to such programs are a number of the largest and most successful public water supply agencies.

Reforestation Work of York Water Co.—It is interesting to consider the initial causes which have led some of these water companies to embark upon reforestation. In this regard the case of the York Water Co., of York, Penna., is worthy of discussion. In a very attractive booklet entitled "York's Water Works," the general manager of the company, Mr. Edgar P. Kable, gives the following very interesting description of the company's reforestation work. He writes as follows under the heading "Reforestation":

"After the dam was filled another problem presented itself, that of preventing erosion of the soil from the

slopes surrounding the basin. The planting of the slopes with grass was suggested. The planting of trees was also suggested and after consulting prominent authorities on picturesque planting, Professor J. W. Toumey, Director of Yale Forest School, was consulted, outlined a comprehensive program and was very reluctant to take any compensation for his services. Professor Toumey is consulted almost annually and takes a great pride in the success of the planting. The wooded tracts were allowed to remain, except that all chestnut and softwoods were cut down, and where the tracts of deciduous trees reached the flow lines a border of Norway spruce was planted to check the leaves from entering the basin.

In 1913, 50,000 white pines and 5,000 Norway spruce three year transplants were set out, followed by 113,000, 100,000 and 325,000 evergreens in the succeeding three years, and as additional tracts were purchased they were planted in the same manner until today there are planted on the tract over six hundred thirty thousand evergreens which are in a most flourishing condition.

On Jan. 8, 1925, Dr. C. A. Schenck of Darmstadt, Germany, at one time Director of the Biltmore Forest School of Biltmore, North Carolina, and a forester of international reputation, visited the tract and made the statement that it was the best example of reforesting of evergreens in the world.

The trees are inspected several times annually by the State Department of Forests and Waters, and the White Pine Weevil and Sun Scald, neither of which was serious, were the only ailments found, but the hazard causing the most concern is that of fire. Two fires occurred, one in 1915, caused by the caretaker burning brush, which spread over about one acre of European Larch trees planted the previous summer, and the other in 1925 when a State Department of Highway workman was burning brush along the Susquehanna Trail. This spread over four acres of Red Pines about three feet high. The State made satisfactory settlement for this loss. Numerous fire fighting tools, including rakes, axes and liquid and dry chemical extinguishers, are kept for instant use and the local fire wardens are within call at all hours. The fire department of the village of Jacobus is also suject to call."

Forested Watersheds as Revenue Producers.—Forested watersheds, aside from protecting the water supplies, can be kept attractive and made revenue-producing by the practice of forestry. The character of the original York watershed, which was mostly open farm land before it was converted to its present use, has naturally precluded, so far, the need for other forestry than the reforestation which has just been described. Later wood products can be removed advantageously. Probably there are many other watersheds in Pennsylvania and New York where the forestry so far has been confined almost entirely to reforestation, as at York. Many New York State watersheds now contain more than 500 acres of planted forest, four have more than 1,000 acres and New York City has reforested 2,500 acres. Many of these watershed forests can now or will be able later to do far more than to merely protect and improve the water supply.

The use of these properties for the practice of forestry offers the water company or department many opportunities to secure regular continuing incomes which can be made to more than support the ordinary carrying charges of the forest and at the same time will permit of the development of pleasing landscapes of a type which will increase the intrinsic value of the property.

Reforestation Work of New Haven Water Co.—It is significant that the practice of forestry has already become an acknowledged objective, secondary, of course, to water production, in the program of at least one large and successful water company. As an example of this type of watershed use, the work of the New Haven Water Co., of Connecticut, which owns approximately 20,000 acres of watersheds, is outstanding. This company's attention was focused upon forestry nearly 30 years ago, since which time it has consistently adhered to a policy which has tended to improve its forests through this activity, and at the same time has provided substantial financial returns from a majority of its woods operations. The company plans to continue to utilize forestry as the best means of caring for its watershed. It is now engaged in developing its forests so as to make them normally productive of the best kinds of forest growth. A statement of a part of the management policy of this company is of interest and is here quoted:

The New Haven Water Co., first in acquiring land and later in building up the Eli Whitney Forest to its present size, was actuated by the desire to secure the highest type of natural protection for the watersheds and reservoirs. A well-stocked forest is unexcelled in furnishing this protection. Consequently, the company's policy has been to establish such a forest on open areas and to maintain and improve in quality the existing forest.

. . . the commercial development and operation of a forest is not inconsistent with its functioning as a protection forest. In this particular region the two purposes, protection and commercial profit, can safely be combined. Hence, the policy adopted by the New Haven Water Co., while developing an excellent protection forest, aims to conduct the work so that wood and timber may be sold and the operations made profitable. As a further objective the creation and maintenance of pleasing landscapes is attempted. This purpose also does not need to be in conflict with commercial use.

The popular idea sometimes encountered, that all cutting of trees in the forest must be prevented if good protection and pleasing landscape effects are to be secured, is erroneous. Cutting of trees is the most effective tool which the forest manager has at his command, not only for securing a steady supply of timber, but also for developing and maintaining satisfactory forest landscapes and the best protection forest."

The above statement of the policy of the New Haven Water Co. has been published in an attractive booklet describing its watershed activities. Correspondence with this company and about twenty-five other companies in Connecticut and Pennsylvania definitely indicates that these companies have decided to reforest nearly or quite all of their open lands and have made definite plans to do so. The attitude of these companies undoubtedly reflects the attitude of a majority of the water companies in the northeastern states.

In addition to their power to yield satisfactory revenues from the practice of forestry, selected areas from these forested watersheds can well be used for public recreational purposes without detriment to the quality of the water supplies and with many advantages to the local populations. Outdoor recreation in forest areas can be provided at a minimum of expense as compared with its cost in highly specialized municipal parks.

Acknowledgment.—The foregoing is an abstract of a paper presented at the second annual conference of the Virginia Water and Sewage Works Association.

EDITORIALS

The 7-Year Rain-Cycle and Its Cause

IN the "Monthly Weather Review" of October, 1920, H. W. Clough says: "It is evident that while the 11-year period is that most prominently disclosed in the variations in terrestrial phenomena, a shorter (7-yr.) variation exists which obscures or masks at times the 11-year period." He gives a table of maxima and minima temperatures from a peak in 1792 to one in 1916. We note that 11 of the 19 peaks there given fall within a year of a theoretically perfect cycle of 7 years, if the year 1917 be called a peak year. By the binomial formula of probability there is but 1 chance in 13 that this correlation is accidental.

Clough speaks of the fact that Douglass found frequent evidence of a 7-year cycle in the radial growth of Arizona pines. Clough does not mention that Sir Arthur Schuster, by the periodogram method found a sunspot cycle of 7 years, as well as one of nearly 7.5 years.

In the "Monthly Weather Review," July, 1922, H. L. Moore pointed out what he believed to be an 8-year cycle in rainfall in America. In his smoothed curve of rainfall from 1882 to 1920 there is evidence of 5 cycles of about 8 years. However, this is too few a number to establish the length of such a cycle with accuracy. The editor has found a 7.5 year rain cycle that fits Moore's curve very well. Ater ("Monthly Weather Review," February, 1926, p. 50), by using the Schuster periodogram method, has found a rainfall cycle of about 7.5 years in eastern United States. It happens that during the 40 year period investigated by Moore, the peaks of the 7-year and 7.5-year cycle were not far apart.

The editor has found that the 7-year cycle is due to a coincident maximum effect of the earth's two great magnetic fields and that the 7.523 year cycle is similarly due to Mars. In a later article both of these cycles will be discussed at length, so the present article will be confined to a brief announcement of the three weather cycles caused by the positions of the earth's magnetic axis.

By assuming that the poles of the magnetic axis of the earth's Heaviside layer of electrons rotate clockwise around the earth's axial poles, it can be shown that the earth should produce a sunspot cycle oftener than every 12 months. Using the cyclogram method, which is much more reliable than the inspection of a smoothed sunspot curve, the editor has found a sunspot cycle of 10.5 months. A rainfall cycle of the same length discloses itself clearly in the rainfall of Sitka, Alaska, as far back as 1847, or shortly after those monthly rainfall records begin. Also the same rainfall records disclose a subcycle of $1/3 \times 10.5 = 3.5$ months. This subcycle is evidently due to three permanent electron whirls whose axes are about 120 deg. apart in longitude.

A cyclogram of the annual growth (radial) of the Arizona pines from 1462 to 1906 was made, and it disclosed the 7-year cycle very clearly. A probability calculation shows that the odds are more than 2,200 to 1 against this being an accident. A similar periodogram of the annual growth of the California redwoods from the birth of Christ to 1909 also shows the 7-year cycle, although its peaks are not so pronounced as in the Arizona pines. Apparently these sequoias dropped two annual rings that were not accounted for by Douglass, for during several hundred of the earlier years the 7-year peaks occurred 2 years later than they would have occurred had 2 rings not been dropped. These tree cyclograms completely establish the 7-year rain cycle.

In two previous articles the editor established the 11.2-year rainfall cycle by means of the sequoias and the Arizona pines, going back for more than 3,000 years in the case of the sequoias.

The rainpeaks of the 7-year cycle usually have been greater than the 11.2-year cycle peaks in the regions thus far investigated by the editor. The next 7-year cycle peak will be in October, 1931, but its effects are usually quite noticeable for about a year before and after the peak. Since a peak of the 7.523-year Mars supercycle is due in November, 1930, the combined effects of these two rain peaks should make the next 15 months abnormally wet in the northern hemisphere.

Should the Hoover Dam Be Built Now?

MONTHS ago we urged the appointment of several independent consulting engineers to investigate all the practicable sources of water supply for Los Angeles. Judging by the reports thus far made public it has seemed to us that this great water problem has not received adequate engineering study. We have been strengthened in this opinion by a recent report by La Rue and Jakobsen, consulting engineers, to the Eaton Land and Cattle Co. That company claims ownership of 12,000 acres of land and 51,600 annual acre-feet of water in Long Valley above Owens Valley, California. The city of Los Angeles is about to build a $750,000 dam at the mouth of Long Valley. La Rue and Jakobsen state that by building a higher dam at a cost of $1,200,000, not only can the 51,600 acre-feet be stored, but an additional 51,000 acre-feet of flood waters can be captured. This proposed higher dam, it is said, can not be built under the city's present easement, and the purchase of the Eaton acreage is recommended so that it can be built. These 12,000 acres are offered to the city for $2,300,000. Eaton contrasts the $2,800,000 expenditure needed to secure the additional 51,600 annual acre-feet with the city's proposed $12,556,000 expenditure to secure 98,000 acre-feet in Mono Basin (to the north of Long Valley).

While we have no detailed knowledge of either as to the correctness of these estimates or as to the alleged ownership by Eaton Co. of certain water rights, we need no such knowledge to perceive that when a firm of engineers of the standing of La Rue and Jakobsen advocates the storage of an additional 51,600 annual acre-feet in Long Valley, the least that the city of Los Angeles can prudently do is to employ consulting engineers to report on this matter. In connection with such a report, again we urge the city to have consulting engineers investigate the water resources of Walker River to the north of Mono basin; for, judging by the runoff reported by the California state engineer, Walker River's supply, added to that of Long Valley and Mono basin, would serve Los Angeles for another generation without going to Colorado River.

None of the Los Angeles papers has reprinted, or even commented upon, our previous editorial articles on this subject, presumably because it has been feared

that the Colorado River project might be postponed if all the facts were known. In Los Angeles that project is commonly looked upon as being one that should not be deferred, because of its supposed value to Los Angeles and vicinity. Because the federal government is financing the Hoover (formerly called Boulder) Dam, the Los Angeles public seems to regard this dam as a gift of Santa Claus. It is a "gift," however, that the recipient must pay for, because the sale of power to the city of Los Angeles and the power companies must not only pay interest on the cost of the dam but amortize the investment in 50 years.

As we have previously pointed out, it is a delusion to believe that power can be developed on the Colorado River and conveyed to Los Angeles at as low a cost as it can be generated there even now by steam. At the recent rate of progress in reducing power costs by steam, before half the 50 years have expired, the cost of power by steam will have been so greatly reduced that the Hoover Dam power project will have become twice as big a white elephant as it now is.

Eventually the Colorado River project should be carried through. "If eventually, why not now?" Simply because the interest on some $400,000,000 can be saved for at least ten years.

Although the effort has been made to conceal the fact, more than half the proposed supply from the Colorado is to be used for irrigation. If this is a wise use, why have no engineering reports been made to show the wisdom of it? The engineering reports throw irrigation, power and domestic use all into one mess, and let the reader try to disentangle the mess if he can. If no other reason existed for employing more consulting engineers, it would be reason enough that their job would be to allocate the proposed investment to its three major uses, and to estimate the annual net income to be expected from each of the three.

The truth is that the citizens of Los Angeles have not been adequately informed as to the Colorado River project. No ballot has yet been taken on any appropriation relative to the project, yet the city has signed a contract with the federal government, engaging to buy the major part of the hydroelectric power that is to be generated at the Hoover Dam. Although legal opinions have been given that the officials of Los Angeles can thus bind the city, we remain skeptical as to their legal right so to bind the city. What, indeed, is the worth of a state charter that prescribes public approval of investment in a public project, if the provisions of the charter can be evaded in this manner? Los Angeles is just as truly investing scores of millions of dollars in the Hoover Dam, when it underwrites most of that investment, as if it sold its own bonds for the purpose. Its city officials have underwritten the investment by signing the power contract with the federal government, and they have done this without a ballot of approval. No "friendly suit" in the California court has yet been brought to settle this phase of the question. Arizona has taken legal steps to stop the whole project, and it seems not unlikely that Arizona will raise the very point that we have just suggested. It may be fortunate for Los Angeles if Arizona succeeds in blocking the project at least long enough to force the city to conduct a thorough investigation of all practicable sources of water supply.

A San Diego hydraulic engineer has proposed that the storage of Colorado River be made in a natural reservoir that lies partly in California and partly in Mexico. A tunnel would deliver the water to the coast, and the pumping lift would be nominal. The project is evidently feasible, and he urges an investigation of its cost. He believes that water may thus be supplied to Los Angeles and southern California at much less cost than by the Hoover Dam project. This suggestion and that of La Rue and Jakobsen, not to mention our suggestion of a Walker River project, alone give sufficient reason why Los Angeles should employ not only one but a score of additional consulting hydraulic engineers to examine every feasible source of water supply.

Marconi Also Advances a Theory of Multiple Electron Shells Surrounding the Earth

EVIDENCE of the existence of shells of electrons around the earth is given in an editorial article on another page; and the theory is advanced that those shells account for the fact that clouds occur in layers that are quite widely separated. In the October issue of "Engineering and Contracting" this electron shell theory is expounded at greater length, and it is shown that both radio echoes and magnetic needle pulsations can be accounted for by the existence of several electron shells, some of which are millions of miles in diameter.

Since these two articles were written by the editor, and after one of them was in type, Marconi, the inventor of wireless telegraphy, has published a theory identical with the one advanced independently by the editor. Before the Italian Society for Advancement of Science, on Sept. 11, 1930, Marconi read a paper in which he said: "The existence of various reflecting layers is the best hypothesis on which to base an explanation of long-distance wave transmission which overcomes the curve of the earth. * * * Radio engineers should, therefore, keep in touch with the work of meteorologists and astronomers, but it is equally useful for the latter to keep in touch with the former, owing to the powerful means which modern developments have placed at the disposal of radio stations."

It was the meteorological researches conducted by the editor during the past three years that led him to frame a definite hypothesis of rain cycles based on the electron theory. Study of the electron theory led the editor to the belief that many other electron shells than the well known Heaviside layer surround the earth. Stormer had found radio echoes that required several minutes for the wave to travel to the point of reflection and back to the earth; but he had ascribed the reflection to streams of electrons coming from the sun, whereas the editor ascribes the reflection to permanent electron shells that surround the earth. The editor also gives facts in "Engineering and Contracting," October, 1930, supporting his theory that similar electron shells surround the other planets and the sun itself.

According to newspaper accounts, Marconi "hinted at the possibility of electric exploration of space." He added that the new under-ten-meter radio waves were apparently reflected from an electron shell much nearer the earth than the Heaviside layer, which is about 43 miles above the earth. And he also said that other observations with radio short waves seem to show similar layers at much greater distances. These statements of his are in perfect accord not only with the facts but with the theory presented by the editor in the two articles written several weeks ago but published this month, October, 1930.

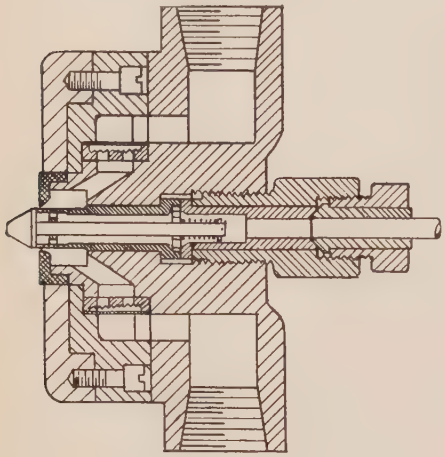
H. P. Gillette

New Equipment and Materials

A New Chlorine Diffusing Device

The Paradon Mfg. Co. of Arlington, N. J., announces the development of a chlorine diffusing device known as the Paradon impulse type dry feed diffusor.

With the impulse type dry feed diffusor, the gas is applied directly to the water or sewage. However, instead of depending on bubbling towards the surface for absorption, a stream of water under high velocity is played on the rising bubbles of gas. This stream is stated to accomplish four purposes: It causes the gas bubbles to take a horizontal path instead of a vertical path, thereby greatly increasing their contact with the water or sewage into which the gas is applied. Second, the high velocity stream minutely divides the bubbles; this action enormously increasing the area of contact between the gas and the water or sewage. Third, the size of the gas bubble being much smaller, its buoyancy is very much less and it therefore will rise to the surface at a slower rate and again more contact with the water or sewage is obtained. Fourth, the high velocity stream of water produces violent agitation of the water or sewage adjacent to the point of gas application; once more effecting a greater contact between the gas and the water or sewage.



The Paradon Impulse Type Dry Feed Diffusor

The manufacturers cite following table of typical results accomplished by the impulse diffusor:

Water Supply (in gals. per min.)	3	4	5
Submergence of Impulse Diffusor (in feet)	Chlorine (pounds per day)		
1	275	350	450
3	350	500	750
5	500	650	750

It is stated that sewage or other liquids could also be used to operate the impulse diffusor, if desirable.

It is further stated that at one installation using impulse diffusors, 200 lb. of chlorine per 24 hours were applied. The water required to operate the diffusor in this case amounted to only 360 gal. per hour.

The impulse diffusor has been in use for approximately one year. Some 25 installations, mostly of medium or large capacity, are now successfully using it.

Klinck Test and Puddle Plug

Harry W. Klinck of Logansport, Ind., formerly superintendent of the Logansport Water Works has procured a patent on a test and puddle plug for use in backfilling the trench where new water mains are laid.

It is customary when laying water mains, to test the joints under pressure before placing the dirt back in the trench. Then after the joints are found to be tight the trench is filled in. If the soil is not tamped in layers as the trench is filled a mound several feet high is usually left over the pipe. Tamping, however, is very expensive and slows up the work considerably.

The test and puddle plug serves two purposes. It is inserted in the end of the pipe and tightened in place. This plugs the pipe and allows the water pressure to be applied for testing the joints. Dirt is then dumped into the trench a few feet behind the end of the pipe to form a dam across the trench. A short piece of 2 in. pipe or hose is coupled into the test puddle plug and water from the main is allowed to fill the trench behind the earthen dam and the soil is dumped into the trench. No tamping is necessary as the soil packs as it is dumped in trench. While the trench is being filled the test and puddle plug may be removed to allow the laying of additional main. By this method the trench may be backfilled as the work progresses and thus eliminate the danger caused from open ditches.

In a comparative test on laying 300 ft. of 6 in. pipe the savings are stated to have amounted to more than the cost of the test and puddle plug.

The Klinck Test and Puddle Plug is being manufactured and marketed by the H. W. Clark Co., Mattoon, Ill.

Cut-In Sewer Connection

A device for connecting a house service with a main sewer pipe without the necessity of placing a Y-branch or T-branch in the line has been placed on the market by The Atlas Mineral Products Co., Mertztown, Pa.

The device is a light cast iron fitting with ball and spigot ends and is made for use with both terra cotta and concrete pipe sewers of all sizes, and for house services of either terra cotta or cast iron pipe of the various diameters usually required.

In making use of the cut-in connection a hole of the proper size is cut in the sewer pipe at the required vertical angle, the spigot end of the fitting inserted, a small amount of jute packed in the space between the spigot of the fitting and the rim of the hole in the sewer pipe, and then the cut-in fitting is held rigidly in place by surrounding the outside of the fitting, as far as the base of the bell, and the sewer pipe itself for a short distance on each side of the fitting, with lean concrete or cement mortar applied with a trowel. There is a bead on the spigot end of the cut-in fitting which prevents the jute or concrete from entering the sewer pipe, and the stops or wings on the side of the fitting allow the spigot end to enter the sewer pipe only so far as to be flush with the inner surface of the sewer and thus provide no obstruction to the flow of sewage. The spigot end of the cut-in fittings of the several sizes and types are so shaped as to fit neatly the inside surface of sewer pipes of the various diameters.

New Small Ditcher

A vertical boom ditcher that is only 4 ft. wide and 11 ft. 6 in. long, and when digging is no higher than a tall man's head is the latest achievement of the Barber-Greene Co. of Aurora, Ill.

The new machine—the Service Special Ditcher—has all of the features of the big Barber-Greenes. It is crawler mounted. It has the vertical boom which allows it to dig right up to a sidewalk or curb, ending the trench flush, and to cut a square corner. As an insurance against strains caused by striking underground obstacles and as a protection to any underground pipes, the machine is equipped with the standard B-G overload release sprocket, a device that automatically stops the bucket line without injuring anything or killing the engine. The construction of this sprocket is such that at every half revolution, it exerts a pull on the bucket line before slipping again, and if the operator desires, he can keep the buckets pounding at the obstacle until it is cut through.

The buckets clean themselves automatically, even in very sticky material. Attached to the boom is a telescoping follow-up scraper for insuring a clean trench. The boom is raised by power, making it possible for the operator to dig accurately to grade at all times.

The Service Special Ditcher

The traveling speeds of the Service Special are 2 miles and 1 1/3 miles per hour. Its speed, small size, and crawler mounting make it highly maneuverable. The ditcher is built throughout of heavy structural steel and is powered by a 33 B.H.P. four cylinder Buda gasoline engine.

Five Dump Body Trucks Added to Ford Line

Addition of five dump body trucks to the line of standard Model AA 1½ ton trucks has been announced by the Ford Motor Co.

The Ford dump trucks include an hydraulic dump body with hoist of 1½ tons normal operating capacity; a heavy duty hydraulic dump body; a mechanical dump body; gravity dump body; and hand dump body.

Bodies are made of one piece of steel with no center or bottom seams to interfere with the free flow of materials.

WATER & WORKS SEWERAGE

Design ~ Construction ~ Collection
Treatment ~ Distribution ~ Disposal

November, 1930 — W. P. Gillette Editor — Vol. LXXVII. No. 11

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Water Works and Sewerage

H. P. GILLETTE, Editor

Vol. LXXVII NOVEMBER, 1930 No. 11

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Water Works and Sewerage

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Separate Sludge Digestion Plant at Topeka, Kan. The Digesters Are Shown at the Left

Separate Sludge Digestion

A Discussion of the Development and Earlier Installations Together with a Comprehensive Study of Five Years' Operating Experience

By E. B. BESSELIERVE

Sanitary Engineer, The Dorr Co., Inc., New York, N. Y.

SEPARATE sludge digestion, as developed and now practiced, represents one of the outstanding achievements in sewage treatment. The theory of the digestion of sludge in a compartment separated in some degree from the compartment in which sedimentation takes place is not new. Records of plant design show that this theory probably had its first application at the Lawrence, Mass., Experiment Station, as early as 1899.

Earlier Work in Separate Digestion.—If digestion in sludge lagoons may be considered separate digestion, one may go back some years further to the work done at Essen, Germany. The first definite recorded recommendations of this method were at Paterson, N. J., in 1906, when the late Allen Hazen recommended it for that city, and the same year, in the report submitted by the Board of Consulting Engineers, comprising Messrs. Rudolph Hering, Samuel M. Gray and Frederick P. Stearns, to the City of Baltimore, Md., they advised that "sludge be removed from the sedimentation tanks at frequent intervals into smaller tanks, these to be operated as septic tanks, in which most of the solid matter of the sludge would be broken up and liquefied." Imhoff, in 1907, recognized the principle of separate digestion in his Emscher tank designs. Birmingham, England, perhaps establishes the first noteworthy example, when this method was actually adopted there in 1912, and Baltimore, Md., followed soon after.

Following the Birmingham plant, developments and modifications were made. One of these, the Kramer tank, consisted of parallel tanks inter-connected, with sedimentation and digestion taking place in different tanks. A single example in this country was installed about 1923, at Palmyra, N. J. Baltimore, Md., built the first outstanding plant, showing the trend toward the modern idea by providing a battery of tanks whose sole function was the digestion of the solids in tanks removed from the sedimentation units. George T. Hammond, Brooklyn, N. Y., in his experiments on the Twenty-Sixth Ward sewage, in 1914 and 1915, studied separate sludge digestion and reported very satisfactory results with a digested sludge equal to Imhoff tank sludge. Provisions in this plant for heating the digester and collecting the gas are early examples of this practice. Alvord introduced his type in 1914, and examples were installed at Madison, Wis., Great Lakes Naval Training Station, Ill., Lincoln, Neb., and a small town in New Jersey.

The Baltimore Installation.—All of this earlier work in separate digestion was done without true conception or knowledge of the process, and consequently the results obtained were not indicative of the ultimate possibilities. Digestion tanks were uncovered, as a rule, and were generally sources of considerable odor nuisance. As a result, separate digestion was not being favorably considered until 1917, and plants then in operation were not proving to be good arguments for the construction of others. Baltimore as previously noted

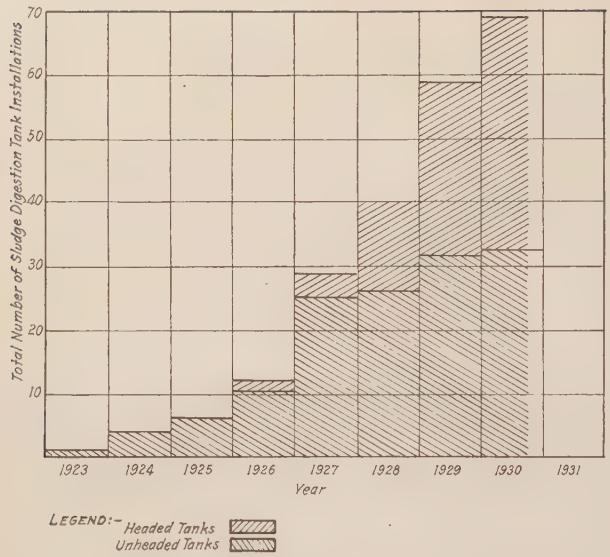


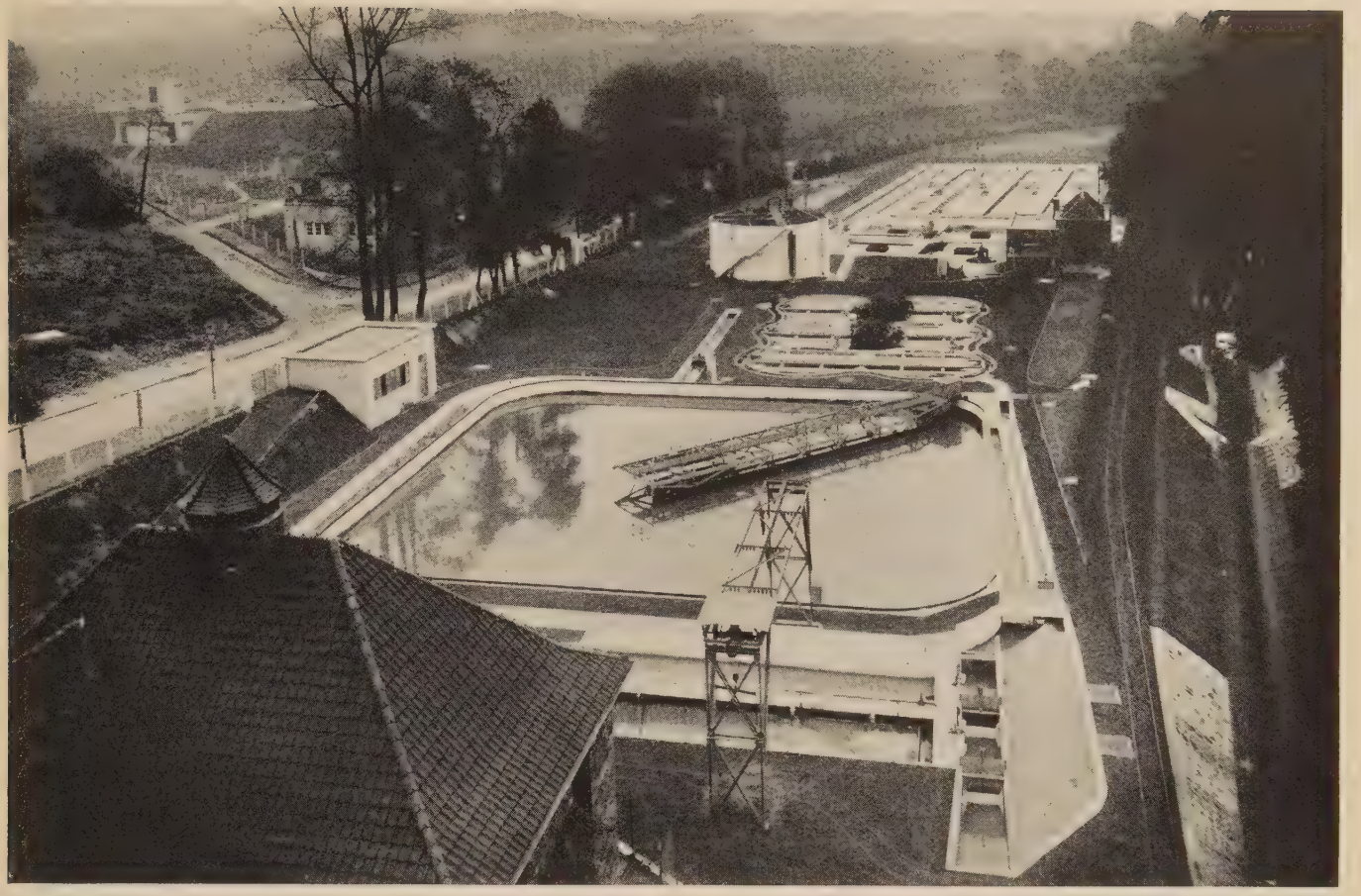
Fig. 1—Chart Showing Number of Sludge Digestion Plants With Mechanical Stirring Equipment in Operation 1923-30

is the first outstanding example of true separate digestion in the United States; that is, the first plant actually removing the sludge from the sedimentation units and pumping it to completely separated tanks for digestion, was having only indifferent success.

Per capita sludge capacities in the Baltimore plant were as much as 9 cu. ft., but the digestion tanks were not producing good results. It may safely be said that these results were due more to the method of operation than to tank design or to the characteristics of the sewage itself. The method of operation at Baltimore was to pass the sewage through the hydrolytic tanks, depositing the sludge and allowing this sludge to accumulate for ten days or more, until a depth of from 3 to 6 ft. had been collected. The tank was then drained and the accumulated sludge was pumped into a clean digestion tank. During the retention period of the sludge in the sedimentation unit, acid fermentation had set in, and all of the sludge actually pumped into the digestion tank was acid. The entire digestion tank, therefore, was filled with acid sludge, and, naturally, a long period of time was required before this sludge overcame this acid step and built up a sufficiently alkaline environment to permit the completion of digestion with the favorable characteristic of that latter step. It was perhaps in 1920 or 1922 that the idea of using shallow sedimentation tanks on sewage and providing a mechanism to clean them was first seriously considered in the United States. However, such use of shallow tanks having no space for sludge storage, and provided with a continuously operating mechanism to convey the sludge to a single outlet, made the frequent removal of this sludge from the tank a necessity. This collection occurred continuously and it was obviously necessary to remove the sludge daily in a volume equal to the amount deposited in the tanks. Therefore, it became necessary to provide a separate tank in which to place this sludge.

The Rochester Experiments.—Experiments were begun at Rochester, N. Y., in 1921, and continued for about 18 months, with a mechanically cleaned sedimentation unit and a separate tank adjacent to it for sludge digestion. Satisfactory results were obtained, which proved to be the inception of much of the research which has continued to this day and improved the process. At the Rochester plant, a stirring mechanism was installed in the digestion tank with the idea that it would produce a more intimate mixture of the raw sludge being added daily and the mass already accumulated, and possibly thereby hasten the first steps of digestion. As scum was common to the older type of sludge digestion tanks, the stirring mechanism was equipped with arms which revolved at the top, whose purpose was to break down this scum and at the same time distribute the incoming raw sludge over the entire area of the tank. Naturally, it was some time before entire success was attained. Several times the tank had to be drained and a new start made, when the entire contents became acid and odorous. Gradually, however, a study of the troubles developed the need for correcting initial acidity, and the use of various reagents was tried with varying degrees of success. After a number of discouraging trials, it was finally determined how acid-

Digester in Separate Sludge Digestion Tank at De Kalb, Ill.



Sewage Treatment Plant at Essen-Rellinghausen, Germany. The Digester Is at the Extreme Left Background. This Plant Was Remodelled Recently, When the Digester Was Installed and Also the Clarifier Shown in the Foreground

ity could be overcome by the use of proper reagents. It was also realized that one of the first principles in the maintenance of proper conditions in the digestion tank depended upon the ratio of raw sludge admitted each day to that already in the tank. It was found that raw sludge up to the maximum of 3 per cent of the total mass of the tank could be admitted each day without upsetting the progress of digestion. On this basis, this meant that a digestion tank must have a capacity of roughly 33 times the amount of sludge removed daily from a given flow of sewage by a given sedimentation unit.

Imhoff tanks had been designed for only 1.0 to 2.0 cu. ft. per capita, and fair results were obtained at a number of places, but in many places there were unexplained difficulties with foaming, heavy surface scums and belching.

The first separate digestion tanks designed on the basis of the Rochetser data contained approximately 3 cu. ft. per capita, which, although higher than the ratio provided in Imhoff tanks, did not prove excessive in construction cost, as the tanks were simple concrete cylinders with 50 per cent or more of their bulk above ground.

The Brownsville, Tex., Plant.—The first full-scale municipal plant of this type was constructed at Brownsville, Tex., in 1923, and, upon the completion of this plant, the experimental work at Rochester was discontinued. The Brownsville plant was the first plant designed entirely on this new basis. A mechanically cleaned sedimentation unit, a mechanically stirred digester and a specially developed pump were installed.

The pump was designed to draw the sludge from the sedimentation unit and discharge it into the digester at rate consistent with the collection of the sludge, and obtain the benefit of a low sludge moisture by reducing the amount of material put in the digester. As the digester was kept full of sludge and supernatant at all times, every time sludge was pumped into it an equal quantity of liquid was displaced. Low sludge mois-

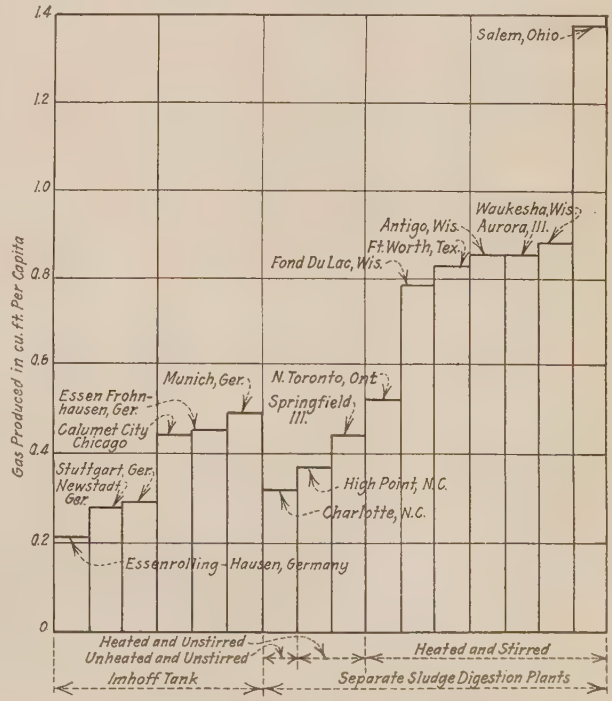


Fig. 2—Chart Showing Quantities of Gas Obtained from Various Types of Sludge Digestion Tanks

tures therefore meant less supernatant overflow to care for. This Brownsville tank was put into operation with a digestion capacity figured at 1 cu. ft. per capita on the population of 15,000 assumed to be the ultimate contributing population. This tank, with few exceptions, has given good results. It is true, of course, that the climatic conditions at Brownsville are conducive to year-round digestion, so that the digestion tank actually does not act as a dead storage tank, as was recog-

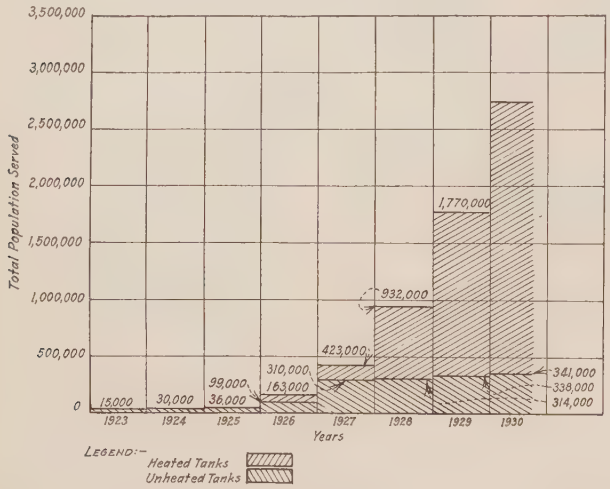


Fig. 3—Chart Showing Total Population Served by Sludge Digestion Plants Using Mechanical Stirring Equipment 1923-30

nized as being the case in colder northern climates. Other plants of this type followed in 1924, at Bartow, Fla., and in several cities in Wisconsin. These digestion tanks were designed on a basis of 3 cu. ft. per capita, realizing that from November to May there would probably be a low temperature in the digester inhibitive to digestion, and the tank must have sufficient capacity to hold a volume of raw sludge for that period. All of these earlier tanks, and, in fact, numerous others up to 1926, were of the open type, in some cases in the southern section without any covering at all, and in the northern climates some with only a board cover to keep snow and ice from them. No attempt was made to heat them or conserve the natural heat of the sludge, or to collect or utilize the gas from them.

Meanwhile, studies and investigations were being conducted, at Rutgers University by Dr. Willem Rudolfs, at Harvard by Professor Gordon Fair, and by others, also. Controlled digestion by the correction or prevention of the natural, primary step of acid fermentation, and the establishment of an environment conducive to maximum bacterial activity at all periods of the year, were the subjects of intensive research. Laboratory and small-scale experimental work proved that these two factors were the most important elements to consider and that they would make it possible to construct plants of this type with an assurance of successful results. The criterion of success was established as the production of a well-digested sludge that would dry easily and without the production of odor nuisances, foaming or scum troubles.

Heating Tanks with Digestive Gas.—Realization that an optimum temperature of 75 to 80° F. was necessary for rapid and successful digestion, even during the winter months, was the father of the idea to heat the tanks. This, however, introduced a potential item of considerable expense, because of the large amount of fuel required to heat and maintain a high temperature during winter weather, and this method of digestion control was not considered practical until it was realized that the process of digestion itself produced the necessary fuel. The gas evolved during digestion was known to be of high calorific value, ranging from 600 to 700 B. t. u. per cubic foot, but serious thought had not been given to its use in heating the tanks. Attempts to utilize this gas had been made at the Peachtree plant, Atlanta, Ga., at Austin, Tex., and experimentally at the Brighton plant, Rochester, N. Y., but only for laboratory and house heating purposes.

A few computations, based mainly on the volume of gas that had been recorded by Imhoff, about .3 cu. ft. per capita per day, showed that it was theoretically possible to heat a digestion tank with hot water coils to a temperature conducive to continued digestion by heating the water with the gas from the sludge of a given amount of sewage.

The Antigo, Wis., Plant.—The first new plant put into operation in the United States employing this principle was at Antigo, Wis., in December, 1926. The digester was equipped with mechanical stirring and provided with a tight, permanent, concrete cover suspended from the same superstructure that supported the mechanism, and with a dome for gas collection. The equipment for burning and utilizing the gas was assembled after discussion with engineers of a gas company. It consisted of a gas meter to measure the flow of gas, a flame trap to prevent back-fires from the boiler, a relief trap to prevent building up excess pressure, a gas-fired boiler of the house-heating type, a circulating pump to force the hot water into the digester, a ring of pipe in the digester to allow circulation of hot water, and an expansion tank as used in house-heating systems. This plant was started in a temperature of 18 below zero and operated in temperatures below freezing for several months. Coal was used to fire the boiler for two months, but after that time gas was being produced to such an extent that at no time since then has any outside fuel been required. Although the theoretical

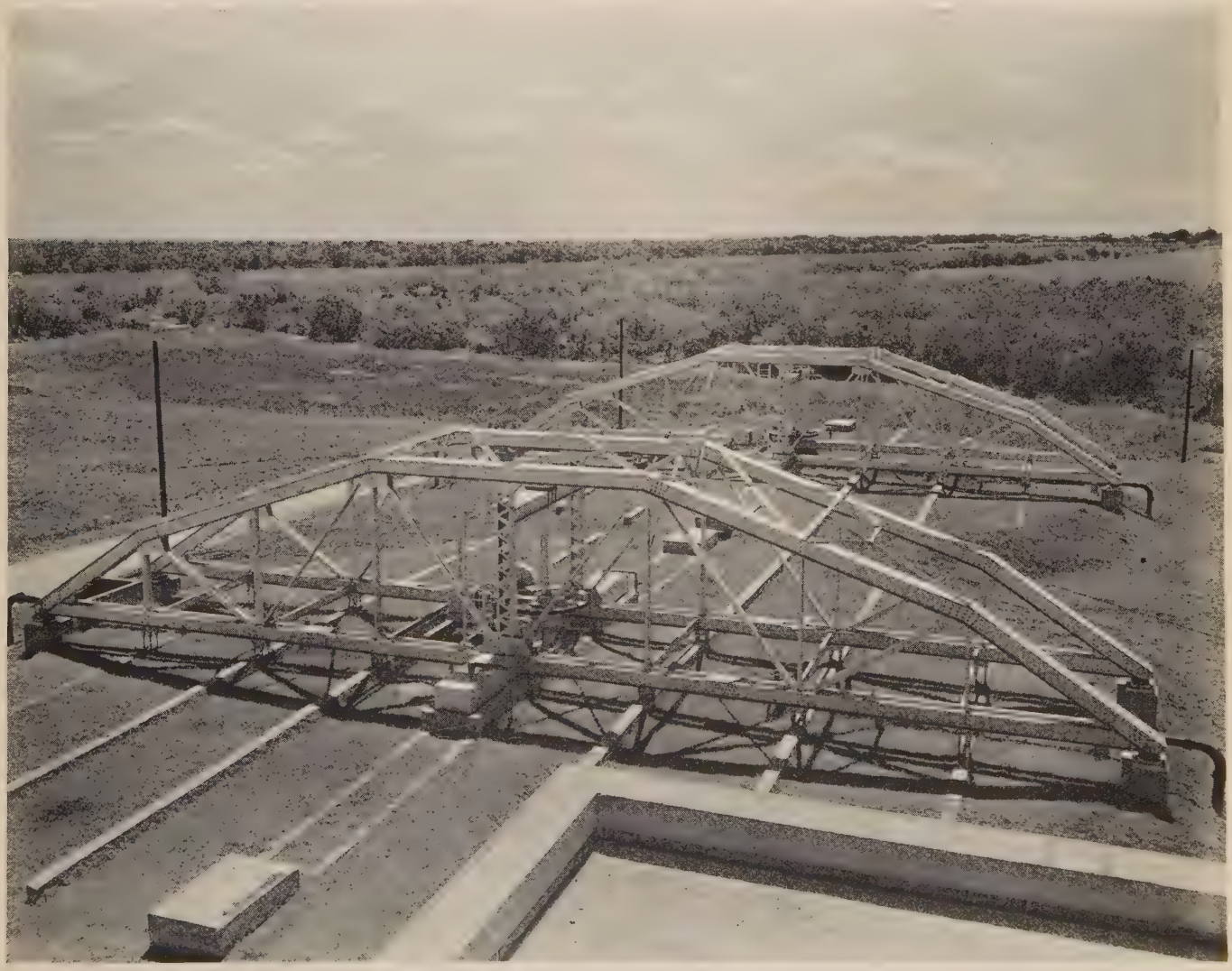
Table I—Gas Production from Sludge Digestion in Various Types of Tanks

Location of Plant	Contributing Population	M.G.D. Sewage	Type of Digester	Gas, Cu. Ft. Cap., Day
Essen-Rellinghausen, Germany	45,000	6.0	Two-story tank (Imhoff)	0.21
Newstadt, Germany	130,000	....	Two-story tank (Imhoff)	0.28
Stuttgart, Germany	35,000	23.3	Two-story tank (Imhoff)	0.29
Calumet, Chicago, Ill.	4,400	1.4	Two-story tank (Imhoff)	0.44
Munich, Germany	500,000	50.0	Two-story tank (Imhoff)	0.49
Charlotte, N. C.	50,000	3.8	Separate, unheated and unstirred	0.32
High Point, N. C.	30,000	3.8	Separate, heated and unstirred	0.37
Springfield, Ill.	75,000	9.4	Separate, heated and unstirred	0.44
North Toronto, Ontario	50,000	6.0	Separate, heated and stirred	0.67
Fond du Lac, Wis.	28,000	3.0	Separate, heated and stirred	0.79
Fort Worth, Tex.	150,000	11.5	Separate, heated and stirred	0.83
Antigo, Wis.	6,000	0.6	Separate, heated and stirred	0.85
Aurora, Ill.	36,000	5.0	Separate, heated and stirred	0.85
Waukesha, Wis.	16,000	2.2	Separate, heated and stirred	0.88
Salem, Ohio	7,000	1.0	Separate, heated and stirred	1.38

gas production of .3 cu. ft. per capita per day had been used in computing this heating system, it was soon found by gas meter records that this rate was being exceeded greatly and that not only was sufficient gas being produced to heat the digester to the desired degree, but also to supply heat for the building.

Gas Production at Antigo Plant.—For the first year the gas production at this plant has averaged between .7 and .8 cu. ft. per capita per day. If this quantity of gas could have been sold at a low rate of 20 ct. per 1,000 cu. ft., it would have produced sufficient revenue in a year to offset the entire cost of the electrical current required to operate all the units of the treatment plant. This rate of gas production has continued right up to the present time and the records from January, 1926, to the present time show an average for this entire period of gas production of 0.8 cu. ft. per capita per day. It is noteworthy in this and other plants that the daily supply of gas is remarkably regular and dependable. Burners may be lighted in the fall and will burn continuously through the winter without attention. Naturally, during the years since the initial design, improvements have been made in the accessories. Now it is the custom to provide individual gas meters for each tank of a battery, to indicate the performance of each unit and thus judge of its efficiency. Automatic furnace control is provided, so that uniform temperature may be maintained in the digester, regardless of the outside temperature, and recording thermometers are employed which give a daily graphic record of the temperature of the hot water going into and the cooler returning from, the digester. The individual gas meters are good indices of tank troubles, because, when one in a battery is not producing the same amount of gas as the others, the operator knows that there must be some reason for that, and investigates. The recording thermometer, showing both in-going and return temperatures of the water, indicate the amount of heat being supplied and permit a check on the number of heat units required and actually applied. Another type of tank, with floating cover, instead of fixed, was introduced in 1925, and in this type it was also recognized that complete submergence of the scum, as well as covering the unit, are beneficial to good digestion and odor control.

The digester at Antigo has consistently produced such a large increase in gas per capita over any other previous type of tank, and subsequent units have sustained this record, that one is brought to the conclusion that stirring must accelerate digestion considerably. It has been a noticeable fact, recorded by independent engineers, that such tanks do not accumulate scum on the surface and that there is also a continuous discharge of gas from the surface. It is reasonable to assume that stirring the mass of sludge at the bottom of the tank tends to open up this sludge mass so that the gas



Two of the Four Digestion Tanks in the Sewage Treatment Plant at San Antonio, Tex. These Digesters Are Used for Digestion of Activated Sludge

is released as soon as formed, and that it rises to the surface in small bubbles, without sufficient bouyancy to carry up sludge particles to form scum. Furthermore, these minute passageways opened in the sludge by the gas cannot help but afford means for the passage of the active bacteria of digestion from the digesting sludge into the fresh sludge.

Odor Nuisance Eliminated.—Operation through several winters for several plants of this type indicates that many of the preconceived objections to this type have been overcome, or, in fact, have never developed. The old fear of odor so noticeable from the older type of tanks has been dispelled. Even those open tanks of the newer type operating in Florida and Texas and other places are doing so without odor nuisance in the immediate neighborhood. In practically all of the newer plants, the type of tank with fixed concrete cover and means for gas collection has been adopted, and these features have been the deciding factor in cities adopting this type of plant. So many of this type are operating successfully that cities have overcome their hesitancy in placing a sewage plant in close proximity to buildings or residences, and, with the development of expert architectural treatment of plant structures, plants have even been placed in sections where property is extremely valuable and where ten years ago a sewage plant would have been anathema.

In some cities this type has been means of saving considerable expense, as, for example, cities on the seacoast, where ocean frontage is the most valuable and yet, at the same time, is the most logical for the sewage plant. To be forced to locate the plant several miles away from the coast, as has been done, and then pump all the sewage back again to a discharge point in the ocean, entails a heavy initial expense for pipe lines and pumping stations and a heavy daily charge for pumping.

In one of the most noted and most exclusive resorts of the country, the beach front of which has been always highly restricted as a park, a plant is now being constructed, embodying all of the newer features of gas collection and utilization, and this plant is entirely below the level of the parked area, a hollow flagstaff acting as a vent being the only structure visible. A plant of this type may be built with safety and assurance of satisfactory results without nuisance to those residing nearby. It is indicative of the recent trend of thought on the part of the public that these plants are actually being built in residential and exclusive sections without protest, whereas, a few years ago, intense antagonism would have arisen.

Operating Separate Digestion Plants.—It has been suggested that separate digestion plants require too much attention. That is not a fact and is recognized now by consulting engineers in general. Many plants are operating daily, using mechanically cleaned sedimentation tanks and the mechanically stirred digesters which do not require more than two to three hours' attention a day for one man. Periodical attention to lubrication, daily removal of sludge, screenings, etc., and occasional removal of digested sludge to the drying bed are the main features of operation. When control of reaction is required, it is a simple matter to instruct the operator in the determination of the condition of his tank, and a few experiments will soon teach him the amount of reagent to add. One man can operate a plant that will handle the sewage from a large population, and the records of total annual operating cost of plants of this type are exceedingly low, as little as $1 per day for all charges, except interest on investment and amortization.

Utilization of Gas for Other Purposes.—Because of the large volume of gas being produced, as shown in Table I, the employment of it for other purposes is being considered. In summer weather, in many plants, this gas may be employed to operate electric generators, thus enabling the city to reduce or dispense with the purchased electric power for these months, thus reducing the total yearly cost. At Charlotte, N. C., this idea has been developed with some degree of success with a low gas production rate of about 0.5 cu. ft. per capita. In this city, at the Sugar Creek activated sludge plant, the gas is used to drive gas engines direct-connected to blowers which furnish air for aeration. It is understood that sufficient gas is produced to allow the operation of the blowers from 10 to 12 hours per day in these months when gas is not required for heating the tanks. In warmer climates, where it is not necessary to heat the digestion tanks at any period and where a reasonably steady flow of gas can be depended upon, this entire production could be used for power purposes, lighting around the plant, laboratory and other purposes. But, whether the gas is utilized or not, a gas collection digester, with completely closed cover and tight dome, is warranted, in the author's opinion; for the simple reason that the gas, which is the sole disseminator of odors, is thus always under control in pipes and may be burned simply as a means of disposal. Burning the gas assures the permanent destruction of all odors. This is now being practiced at a plant in New Jersey, where the gas is burned in the stack of the plant and no complaint from odor or nuisance has arisen from neighbors, after operation for almost a year.

The increasing desire for plants of this type is the best index of their success. The number of plants of this type installed and put into operation since 1923, and the ratio of each year's plants to the total, as shown in Table I, indicates the extent to which separate digestion has taken hold in this country and abroad. It is especially interesting to note that plants of this type have been built in Germany and other European countries by engineers whose earlier developments have been along different lines.

Another year will produce records of operation of almost one hundred plants of the separate digestion type and will be a valuable addition to the recorded data of sewage treatment. Five years' experience is a sufficiently long time to bring out inherent difficulties, if they are likely to develop at all, and it is firmly believed that separate digestion is now on a firm footing of fact and knowledge and may be applied with safety to the handling of settled solids from sewage, whether from raw sewage, activated sludge or trickling filter humus tanks.

Acknowledgment.—The foregoing is a paper presented Oct. 15 at the annual meeting of the American Society for Municipal Improvements.

DALLAS, TEX., ADOPTS CITY MANAGER PLAN.—On Oct. 14 the citizens of Dallas, Tex., by a 2 to 1 vote adopted amendments to the city charter providing for a commissioner form of government. The new city manager will be chosen next April by a council of nine. Dallas, with a population of 200,000, is now the fifth largest city in the country under the manager form of government.

Changing from a Flat Rate to a Meter Basis

Methods Used by City Water Department of Gloversville, N. Y., to Bring About the Adoption of Universal Meterage

By ALEXANDER ORR

Superintendent, Board of Water Commissioners, Gloversville, N. Y.

ENGINEERS and superintendents generally recognize that the meter basis is the only practical business way to obtain revenue from the sales of their products.

Public utilities owned and operated by corporate or private interests universally sell their product on a measurement rate basis and are always in a position to know the exact relation between earnings and output or product for said earnings. On the other hand, municipally operated utilities selling their product on a flat rate basis never know the relation between these two items.

Gloversville has a population of about 23,000 and its principal industries are the manufacture of gloves and the production of leathers of all kinds.

Its water supply system is municipally owned and is a gravity system obtaining its supply from mountain streams in the foothills of the Adirondack mountains. It has a reserve capacity in its storage works of approximately 400,000,000 gal.

The water department of the city is under the charge and control of a board of water commissioners of five members who are elected by the city at large for a term of four years. Its duties and rights are prescribed by a special act of state legislature creating the board.

When the writer became connected with the water department in 1899, the department was facing an acute shortage of water, the storage capacity of the system at that time amounted to approximately 18,000,000 gal. and the end of this reserve supply was in sight. Only the early appearance of a rainy season saved the city from serious consequences.

Water Demand Increased by Change in Manufacturing Process.—About this same time a radical change had been brought about by the leather manufacturers in the methods and processes of tanning and dressing leather. Prior thereto the time consumed in producing finished leather from the raw stock was from 2 to 18 months. New processes of tanning and dressing were perfected so that at the present time the same leathers are produced in from 6 to 14 days and of a much finer quality in every respect.

The city water is very clear and soft. The total hardness runs from 22 to 30 and is claimed by leather dressers to be the finest water for leather dressing purposes in the world. Due to its softness and relative freedom from minerals in solution the tanners are able to produce leathers of the finest texture and finished in the softest shades of all colors.

This change in the methods of dressing leather increased very greatly the amount of water used by the tanners and in order to preserve the industry to our city it was immediately necessary that the board of water commissioners take steps to provide the necessary additional supply.

At this time the city had already taken over and was using all the available sources of supply and the only method left to increase the water supply was the development of storage works on one or more of the streams supplying the city. The board immediately made plans and took steps to carry out a building program looking to the creation of additional storage capacities and enlargement of city mains to make such additional supplies available.

At the same time the board was strongly impressed with the fact that steps should also be taken to prevent the loss by waste of such supplies and that the daily consumption should be reduced as nearly as possible to legitimate and proper uses.

Cutting Down Water Waste.—House to house inspections had been periodically made for some years past and the tabulated results from such inspections always revealed that from 50 to 75 per cent of all service pipes had one or more leaky fixtures connected therewith. Orders to repair forthwith served on the owners of the properties affected would bring about some immediate response, but generally there was a neglect in repairing the defective fixtures and the board soon became convinced that the house to house inspection was of little use and decided that the only way to conserve the water supply was to adopt the meter system.

At this time the board had in effect a classified meter service which compelled all service pipes leading to manufacturing plants, hotels, livery stables, laundries and business blocks to be metered. This classified list had been in effect for some years and about 300 meters were in use.

The First Step in Combatting Opposition to Meterage.—In arriving at the conclusion as stated the board realized that there would be serious opposition from certain interests against universal meterage as soon as their plans became generally known. As one step to combat this opposition they decided to buy 100 meters, to be placed on domestic services where it was thought the effect would do the most good for the plan. Very often some property owner having a small family would object to the water tax he was paying under the flat rate as compared with some neighbor with a large family, who was paying the same rate. Here it was suggested to him that he have a meter placed on his service pipe and thus pay for his actual use. Instances of this kind, together with applications for meters from others who were interested in the proposition, soon used up the hundred meters and the board was obliged to buy more to meet such requests.

The next move was to add to the classified list all service pipes leading to boarding and lodging houses.

A further study of the tabulated results of house to house inspections showed that one particular type of fixture, the hopper closet, was a serious waster of water and that there was about 500 of these in use. The board immediately ordered meters placed on all service pipes leading to properties having such closets.

The board then passed a resolution and ordinance requiring all new and all re-placed service pipes metered. This resulted in 100 to 120 additional meters each year.

Results of Meter Installations Bring General Ordinance.—In 1907, the board, after a study of the results of the meter installations as heretofore cited, enacted and passed a general ordinance requiring all service pipes connected to the water supply system of the city

to be metered, that all water supplied to said service pipes be at the existing schedule of meter rates, and that the meters necessary to carry out the foregoing ordinance be bought and installed as fast as the finances of the department would allow.

This action started the fireworks. Letters and newspaper articles appeared in the daily press from the opposition. These articles were met by articles written and published by several consumers who had had for some time meters on their service pipes and gave encouragement to the board to proceed along the lines settled on. Some of the articles from the opposition were answered by the board giving a general description of the waste of water on specified premises and described in such a way that everybody knew who owned such properties without naming the specific objector. One such objector who made the biggest howl came out in the press with a letter stating that he had investigated the meter proposition in reference to a number of cities and that all of the cities mentioned the adoption of meters would not be tolerated. The writer immediately got in touch with the water departments of the cities referred to and immediately received replies that the meter system had been adopted and that meters were required on all service pipes and that those not yet metered were gradually being metered. This objector's original letter was then again published together with the replies received by the writer from the cities referred to and no further opposition came from this objector's camp. The last wail of the opposition was to conduct a voting contest on the question of adopting meters in the daily press by means of a coupon to be filled out and mailed. Of course, these coupons were filled out and mailed in by everybody no matter whether they were city or rural residents. However, before the final count was made (if it ever was) the city water works system was 70 per cent metered and water consumers were still asking for meters on their service pipes of their own volition.

The final work of metering unmetered services was carried out by taking one street in each of the six wards and ordering and placing meters on service pipes not already metered. This method was repeated from time to time until all the city was covered. On Jan. 1, 1913, the water board was able to report the city 100 per cent metered.

The Schedule of Meter Rates.—The schedule of meter rates in force up to 1909 was based on an average daily consumption and was in terms of gallons. This schedule was found to be in many cases unfair and cumbersome and in 1909 the following schedule was adopted:

	Cents per 100 Cu. Ft.
For the first 5,000 cu. ft.	12
For the next 5,000 cu. ft.	10
For the next 5,000 cu. ft.	8
For the next 5,000 cu. ft.	6
For the next 5,000 cu. ft.	4
For the next 5,000 cu. ft.	3
For all over 30,000 cu. ft.	2½
Minimum charge per meter for 6 months	$2.00

The above schedule was in effect until 1917 when the last two items of the schedule were eliminated making all water used over 25,000 cu. ft. at 3½ ct. per 100 cu. ft.

Effect of Meterage.—As to the effect of installing meters on domestic services we find that generally 80 per cent of such consumers saved money or broke fairly even as compared with the old flat rates. The other 20 per cent paid for what they used and wasted and more than made up for the loss due to the savings of the other 80 per cent. Any suggestion today in the city of Gloversville to return domestic consumers to a flat rate schedule would not be tolerated by the majority of such consumers.

Under the former flat rate system water taxes were collected from the whole city every six months in May and November. As the number of meters set began to increase it soon became evident that the billing work, etc., connected with meter accounts would make this method cumbersome and impracticable. The city was, therefore, divided into three collection districts, each district collected every six months and thus giving a collection in the office every two months. This change simplified the work and keeps a steady stream of work going through the office and a steady stream of money coming in. The entire work of figuring, billing and collecting water taxes together with all other clerical work of the department is done by 2 people.

The entire work of reading, setting, replacing and repairing of all meters is done by 3 men. At the present time we have 5,230 meters installed, all read four times a year, twice for collection and twice for checking.

In conclusion, the writer from his experience believes that all communities are alike to a great extent, the proportion of fair minded tax payers is in a majority, the opposition to be met against a meter rate basis is due largely to ignorance on the subject and a small amount of education will swing this opposition to support. There will always be opposition, however, from certain elements who know that under the meter basis they will have to walk up and settle in full for what they are receiving to a great extent free under the flat rate schedule.

In Gloversville today and for several years past we do not know or fear a water shortage. We are satisfied that the universal adoption of a meter basis in our city has been a great factor in conserving our supply and bringing about this condition.

Acknowledgment—The above is an abstract of a paper presented before the New York section of the American Water Works Association.

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Furnishing Water to Contractors

In a discussion in the Superintendents' Round Table at the St. Louis convention of the American Water Works Association, Mr. C. W. Winkle, superintendent of maintenance and transportation, Indianapolis Water Co., state that his company furnishes water to contractors from fire hydrants, but it is under the supervision of one of their employees. A 2-in. valve connection is put on one of the nozzles of the hydrant, the hydrant opened up full and then the contractor operates the hydrant from the 2-in. valve which is reduced down to about, in most cases, a 2-in. opening and the water company man looks after this contracting work and closes and opens them at nights and mornings. The fire department is notified where these hydrants are equipped with the contractor's connection. If it is on a street that has been blocked off for several squares the company does not close it up each night and open each morning until the contractor gets through. The fire department is prepared for the contractor should they have to get into the street. They understand that when they get to this hydrant with the 2-in. valve connection on the 2½-in. nozzle they first have to close the hydrant before they can make connections thereto. Very good results have been had in this way of handling contractors.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
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Air-Binding of Filter Beds

VERY few filter beds are free from air-binding troubles all the time, and while the release of air in the sand beds is not a serious problem in most filtration plants, it proves quite troublesome at times in a few plants. It is well known that water exposed to the air contains dissolved gases. The saturation points of the various gases in contact with water have been worked out years ago, and have been described fairly well in the chemical literature. Equations are available for computing most of the variations due to changes of conditions, so that saturation equilibrium can be calculated for most any condition. There is one thing that has to be determined experimentally, and that is the amount of gas that will dissolve in water at some given temperature and pressure. When this is determined for one condition it can be calculated for most any other condition.

As many of the engineers and chemists engaged in water treatment may not have all this information readily available, it is believed desirable to review some of the well known facts. This may seem somewhat elementary to advanced chemical students, but owing to the fact that air-binding is a factor almost ignored in the design of filtration plants, there is some justification for thinking perhaps many of those designing and operating such plants are none too familiar with the fundamentals of air-water equilibrium. Much of the present article will be arranging known chemical facts in a form more suitable for general use in water filtration, hoping that it will not be necessary for the reader to make extensive search of the literature.

Chemical Laws Governing the Solution of Gases in Water.—As stated, there is no law to predict the quantity of a given gas that will be absorbed by water, but once its equilibrium has been established for one condition the influence of temperature, pressure, and the presence of other gases may be computed fairly accurately.

Avogadro's law states that equal volumes of all gases under the same condition of temperature and pressure contain the same number of molecules. The molecular weight of oxygen (O_2) is 32, and a molecular (one mol) volume of gas is the volume of 32 grams of oxygen. The molecular (mol) weight of a gaseous substance is that weight which occupies a molecular (mol) volume. At 0° C. and 760 mm. of mercury (one atmosphere), the volume for one mol of oxygen (32 grams) is 22.410 liters.

Boyle's law states that at any constant temperature the volume occupied by a quantity of gas is inversely proportional to the pressure exerted upon it. The pressure in atmospheres multiplied by the volume of a mol weight equals a constant.

The usual chemical method of expressing the composition of a mixture of gases is in terms of the mols of each substance present. The air is approximately 23.25 per cent by weight of oxygen, 75.50 per cent nitrogen, and 1.24 per cent argon. Reduced to mol ratios, each mol of air contains 0.210 mol of oxygen, 0.781 mol of nitrogen, and 0.009 mol of argon.

Dalton's law states that in a mixture of gases each exerts its pressure independently of the others; that is, the partial pressure of one gas is unaltered by the presence of another gas which also exerts a partial pressure. To illustrate: if two liters of nitrogen gas at atmospheric pressure are mixed with one liter of hydrogen gas at the same pressure, there will be three liters of the mixed gases, which will be two-thirds nitrogen by volume and one-third hydrogen. The nitrogen will exert two-thirds of the pressure and the hydrogen one-third. According to Avogadro's law the mol ratio of the mixed gases will be 0.667 and 0.333 respectively and each gas will exert a partial pressure in proportion to its mol ratio. Another illustration might be given in which one liter of nitrogen gas at atmospheric pressure is forced into a vessel that contains one liter of oxygen at atmospheric pressure. The combined pressure will be 2 atmospheres, for each gas in the vessel will exert independently of the other a pressure of one atmosphere. Forcing another liter of some other gas into the vessel will produce a pressure of 3 atmospheres, each of the three gases exerting independently a pressure of 1 atmosphere.

Henry's law states that the solubility of a gas at a given temperature is proportional to the pressure of the gas above the solution. This means that if a certain volume of gas is absorbed by a liter of water at atmospheric pressure, twice the amount will be absorbed at a pressure of 2 atmospheres. One atmosphere is equal to a head of 33.93 ft. of water, and each foot of head or each foot of suction increases or decreases respectively the amount of gas which will be absorbed by approximately 2.95 per cent.

These chemical laws may not be absolutely correct for all conditions, but are so nearly accurate there will be no appreciable error in using them in computing the solution equilibriums of gases in water. The charts in Fig. 1 and 2 illustrate the effect of temperature and pressure on the absorption of gases by water.

Solubility of Gases in Water.—The solubility of gases in contact with water at 0° C. and 760 mm. of mercury (one atmosphere) are given in Table I. This is based upon the water being in contact only with the gas being absorbed.

Determining the Gas Saturation Equilibrium.—To illustrate how the gas saturation equilibrium may be determined for any given condition, we will assume the water in a certain stream at a temperature of 5° C. is

Table I—SOLUBILITY OF GASES IN WATER AT 0° AND 760 MM. MERCURY

Gas	Volume in CC. of Gas per Liter of Solution	Weight in Grams of Gas per Liter of Solution
Oxygen	48.90	.06948
Hydrogen	21.48	.00192
Nitrogen	23.88	.02977
Chlorine, 10° C.	3,095.00	9.969
Carbon monoxide	35.37	.0440
Carbon dioxide	1,703.00	3.347
Hydrogen sulfide	4,686.00	7.100
Ammonia	1,298,900.00	987.00
Sulfur dioxide	79,789.00	228.30
Methane	55.63	.0396
Ethylene	226.00	.2810
Acetylene	1,730.00	2.000
Air	28.81	.0372

saturated with air. Water from this stream is used in a filtration plant, and in passing through the treatment process before it reaches the filters the temperature is increased to 10°. The curve for air in Fig. 1 shows the saturation equilibrium to be 25.5 cc. of air per liter of water at 5°, and 22.5 cc. at 10°. This is 3 cc. in excess of the saturation point, or 13.3 per cent supersaturation as a result of the increase in temperature. It might be well to state that the saturation point of air in water at 0° C. is approximately 38.8 cc., or 37.2

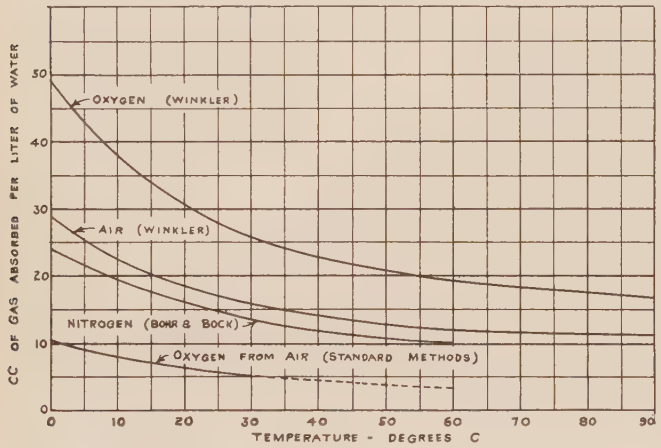

Fig. 1—Relation Between Temperature and Volume of Gas Absorbed

parts per million, and not 63.8 parts per million as given by Ellms[1].

We will assume that the filters in this plant were constructed for a total loss of head of 10 ft., with the water level about 5 ft. above the top of the sand beds. Assuming 1 ft. loss of head as friction through the sand and the underdrains when the filter is first put in operation after being washed, this allows a suction of probably 3.5 to 4.5 ft. to be exerted on the water in passing the beds when the losses of heads are at the maximum. The chart in Fig. 2 shows that for 4 ft. suction, the equilibrium of air at 10° C. is 19.7 cc. Taking into consideration both the effect of temperature increase and suction, and computing the excess of air as being the difference between the original saturation equilibrium and its equilibrium under maximum suction in the beds, the supersaturation is about 29.4 per cent. It is evident that such a condition will produce serious air-binding troubles.

In most filtration plants, and especially the larger ones, there is little or practically no increase in the temperature of the water in passing through the plants, but there are a few cases where the temperature does increase. Very likely there are cases where the water increases in temperature on warm days in storage reservoirs prior to filtration and causes the water to become supersaturated with air. In a few plants the water is passed over steam engine condensers, which increases the temperature several degrees.

Conditions That Cause Water to Become Supersaturated with Air.—When water is saturated with air at atmospheric pressure, the factors that cause supersaturation are as follows:

1. Increase in temperature.
2. Decrease in pressure.
3. Increasing the pressure while the water is in contact with air bubbles, causing more air to dissolve, then reducing the pressure to normal.
4. Formation of gases within the water as a result of chemical or biological action.

The effect of temperatures is illustrated by the curves in Fig. 1. The effect of changing the pressure follows Boyle's law and is illustrated in Fig. 2.

Increasing the pressure while the water is in contact with air bubbles is typical of what happens in a few plants where the water is pumped in advance of filtration. Where the water going to the pumps is under suction, it is difficult to avoid air leaks in the suction pipes or the packing glands of the pumps. Then when the air bubbles pass the pumps and are thrown under pressure the bubbles go into solution, tending to establish an equilibrium for the increased pressure should enough air be present. When the pressure is released in the mixing basins and the settling basins of the filtration plant the water may be considerably supersaturated with air.

There are several references in the literature to supersaturation of water with air due to air bubbles getting into the water and the water immediately afterwards forced under pressure. No doubt there are many other known cases as well as many cases where this is the cause but is not known. Hatfield[2] describes serious air-binding of filter beds at Highland Park, Mich., due to leaky packing glands on a pump. Fields[3] also describes a similar cas. Leak in the suction lines to pumps is not the only way air bubbles may get into the water. The writer[4] gave account of a case where water was allowed to fall into a chamber that led into a tunnel which was under about 35 ft. head of water. Air was churned up in the water as it fell into the chamber, and the chamber being small the bubbles were carried on into the tunnel with the water. The saturation equilibrium of air in water under 35 ft. head of water is more than double the equilibrium at atmospheric pressure, and it is likely that the bubbles went into solution quite readily.

More air-binding, it seems, is attributed to microorganisms causing a supersaturation of oxygen in the water than anything else. As to the correctness of this assumption, there is considerable doubt in the mind of the writer, for many plants where the microörganisms are so few that they could not possibly increase the dissolved oxygen materially there is considerable air-binding at times. The increase in dissolved oxygen very likely is a contributing cause in a number of plants. Powell[5] states that air-binding is more frequent in winter than in summer due to the water increasing in temperature in passing through filtration plants. He also states that when there is air-binding in the summer it is traceable usually to prolific algae growths, and that under some extreme conditions the supersaturation of dissolved oxygen may rise to 200 per cent. The writer has never come in contact with water used for a public supply that had more than a slight excess of dissolved oxygen due to algae growths, but does not question the

statement that such organisms cause the water to be greatly supersaturated with dissolved oxygen in some waters.

Influence of the Supersaturation of One Gas on the Saturation Equilibrium of Air in Water.—As many filter plant operators attribute most of their air-binding troubles to increases in the dissolved oxygen due to algae being present in the water it might be well to see what influence increasing the oxygen has on the saturation equilibrium. Perhaps some get the impression that a certain per cent excess of oxygen represents that much supersaturation. This is not the case. Assume a 20 per cent excess of dissolved oxygen over the amount normally in the water, and assume the temperatures to be 10° C. Computing the dissolved oxygen from the table given in Standard Methods of Water Analysis, there is approximately 8.0 cc. of dissolved oxygen at this temperature when the water is at equilibrium with the air. Twenty per cent excess would be 1.6 cc. Now if we could assume that this excess was air it would be easy to calculate the supersaturation to be approximately 7.1 per cent, but the gas escaping in the sand beds would not have exactly the composition of the gases of the air. The oxygen ratio would be slightly higher, and as oxygen is more soluble than nitrogen the saturation equilibrium would be different. Instead of the supersaturation being 7.1 per cent, it would be somewhat less. With highly soluble gases such as carbon dioxide a material increase in the amount of carbon dioxide in the water does not increase the supersaturation of air very much.

The Point Where Air Is Released in Filter Beds.—It must have been the opinion of a few some years ago that air is released in the gravel of the filter beds, for we find Caird[6] stating that: "The voids in the gravel are greater than in the sand, therefore the air collects in the gravel." As a matter of fact the air first collects in the sand and it is only under very extreme conditions where it extends down into the gravel. The writer has made many observations on the release of air from water in glass tube filters, and finds that the first air always occurs near the surface of the sand beds, frequently less than 1 in. below the surface. Is this not the place where we should expect it to start? It is the point where there is the greatest suction head, also the point where the air remaining in the bed in the form of small bubbles that are not washed away during the washing period usually collect. It will be explained later that the release of air under conditions occurring in filter beds cannot start without the presence of air bubbles or a gas surface to give a starting surface.

Negative Head in Filter Beds.—If a filter bed shows a loss of head of 1 ft. when first put into service after washing, probably three-fourths of this loss is friction through the sand and gravel, and the balance is through the underdrains. Of the loss in the sand, it is believed that approximately one-half is within the top 2 in. of sand. Practically all increase of loss of head as the filter continues in service is in the top of the sand beds. It never increases materially below the point where the coagulated matter is deposited, which usually does not penetrate into the beds much more than 2 or 3 in. except when the water is near the freezing point. It might be said that for most filtration plants there is practically no increase in the friction losses below the top 2 or 3 in. of sand, except possible for a short period during the colder months in a few plants. Even then the major portion of the increase is in the top 3 in. These statements apply to portions of the sand beds free from surface or side cracks.

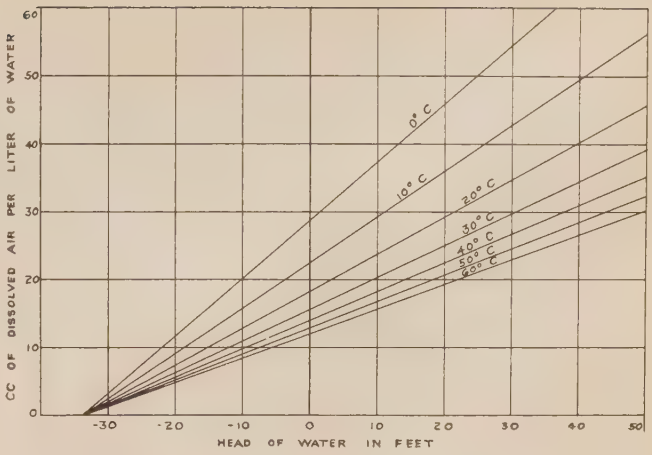

Fig. 2—Effect of Pressure on the Air Absorbed by Water

Fig. 3 shows profile of the pressure on the water as it passes through a filter, using atmospheric pressure for the zero line WA. In this case the sand surface is assumed to be 4 ft. below the water level, and is at the vertical line through S. D is the line at the underdrains. The total loss of head on the filter is assumed to be 1 ft. at the start of the run and 8 ft. at the end of the run. It will be assumed that the valve on the effluent line is 10 ft. below the water level on the filter. When this valve is cut off the head on the water below the water surface is a straight line WX, and when the filter is put in operation the head follows the line WSDT. The line WS to the sand level is always the same and is always above the zero line, but SDT keeps dropping down as shown by the line $SS_1D_1T_1$ as the loss of head increases. If the water is just saturated with air there will be no escape of air so long as the point S_1 does not fall below the atmospheric line WA. The condition shown in Fig. 3 is characteristic of every filtration plant. As the distance from the water surface to the sand surface varies the curve for head on the water shifts along the line WX. S may be found at most any point along the line in various filtration plants. If S is at the 8 ft. line; that is, 8 ft. below the surface of the water, there will be no negative head when the total loss of head is not over 8 ft. Supersaturation of the water is equivalent to shifting the point S towards W, and when the water is less than saturated it is equivalent to shifting S towards X.

Computing the Volume of Air that May Be Released in a Filter Bed.—A rapid sand filter bed of 1,000,000

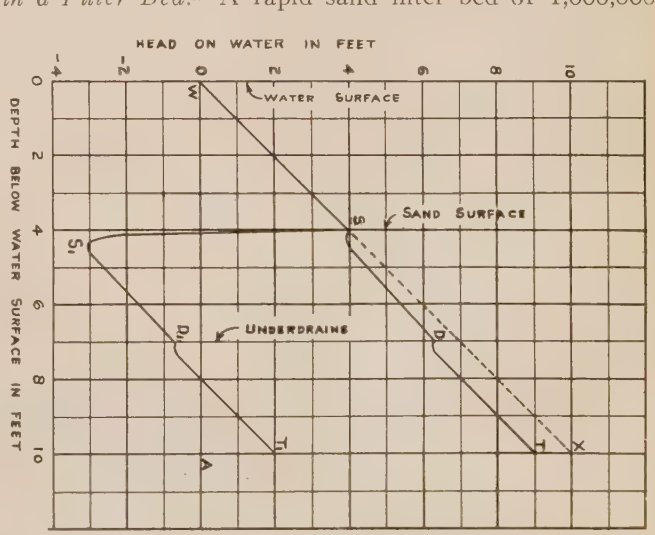

Fig. 3—Head on Water as It Passes Through a Rapid Sand Filter

gal. capacity, when operated at the rate of 2 gal. per square foot per minute, will have approximately 347 sq. ft. of filtering surface. Assume the voids in the sand that may become filled with air to be about 30 per cent of the volume, this will give about 104 cu. ft. of voids for each foot of depth in the bed. When the water at 10° C. is just saturated with air, a suction of 1 ft. on the water will supersaturate it to the extent of 0.685 cc. per liter, or 0.000685 per cent of the volume of the water. This is determined by the line for 10° in Fig. 2. For 1,000,000 gal. of water this would give 685 gal. of air, or 91 cu. ft. This is approximately 3.8 cu. ft. of air supersaturation per hour per 1,000,000 gal. capacity at 1 ft. suction when the rate of filtration is 2 gal. per square foot per minute. If all the supersaturation was released in the sand bed, which most likely it will not be, this would fill the sand voids to a depth of 0.036 ft. per hour, based upon an even distribution of the air throughout the bed. With 3 ft. suction the air released, if all the supersaturation was released, would be 0.108 ft. per hour, or 11.4 cu. ft. Assume only one-half of the supersaturation is released, which probably is more near what actually takes place, and assume the filter ran for 4 hours with a negative head of 3 ft., about 22.8 cu. ft. of air for the four hours might be expected. This is enough air to cause considerable bubbling when the filter is cut off to be washed, and to cause the unsightly foam to collect on the surface of the water during the washing. Not only is the foam unsightly, but it carries away considerable sand with it.

The conditions just explained probably are somewhere near actual conditions that are likely to occur in most any filtration plant where a negative head is produced in the upper part of the sand beds before the loss of head reaches the maximum. As the water in flowing through is only a very short time within the location where there is negative head, it is evident that the rate at which the air will be released is of importance.

Rate of Air Release in Supersaturated Water.—What are the factors which govern the rate at which air will be released from water? There is not much information on this subject. Whitman and Davis[7] confirm Bohr's conclusions that the rate of escape of sulfur dioxide from water is about the same as the absorption rate. Very likely this is true, or nearly true for all gases. As absorption of gases has been given more study than the escape of gases from water, it might be well to review some of the work on absorption rates.

Lewis and Whitman[8] state that when a liquid and gas come in contact in a quiet state there exists on the gas side of the interface a layer of gas in which motion by convection is slight, and that similarly on the liquid side of the interface there is a surface layer of water which is practically free from mixing by convection. Any transfer of gases through the films must be by the very slow process of diffusion. These authors also state that with gases of low solubility such as the gases found in the air, the gas layer at the interface has no appreciable effect and the absorption rate is determined by the layer of liquid on the liquid side.

Perhaps many are not aware that the thickness of the layer on the surface of the water varies considerably, depending upon the time it has stood in contact with the air. Mr. Frank Hannan several times has called the writer's attention to the very thick surface film formed on the water surface after it has stood in contact with the air for a short time, and has stated that the transfer of gases through this film is extremely slow. Lewis and Whitman give the formula

$$\frac{dW}{dO} = K_L A (C_s - C_L)$$

for the absorption rate of gases.

$\frac{dW}{dO}$ = rate of absorption in grams per hour.

W = weight of gas absorbed in grams.

O = time in hours.

A = area of liquid-gas interface in square centimeters.

K_L = diffusion coefficient through liquid film.

C_s = concentration of the gas in water in equilibrium with the gas, in grams per cc.

C_L = concentration of the gas in the main body of the water, in grams per cc.

The coefficient K_L varies greatly, depending upon the age of the surface film. Adeney and Becker[9] found K_L for atmospheric gases to be about 0.4 for quiet surfaces at 15° C., and calculated the film thickness to be 0.17 centimeters. By bubbling gases through water, Lewis and Whitman found the value of K_L to be about 60.0, and calculated that it corresponded to a film thickness of 0.0011 centimeters. If these computed film thicknesses are correct, then the film around a bubble rising through the water is less than 0.01 the thickness of the film on a still surface. The coefficient K_L and film thickness for several gases under varying conditions are given in Table II.

The question is, which of the values for K_L nearest approaches that of the water passing through a filter bed when it comes in contact with the air which has collected. Even after enough air has collected in the bed to equal a depth of several inches there are still places where the water will flow through without coming in contact with the entrapped air. There will be other places where it is making its way through the entrapped air in very thin films or very fine streams. The quickness with which the air is released indicates that the coefficient K_L is nearer 60.0 and 0.4, though the extreme thinness of the streams or films of water may have great influence. Assuming 40 per cent voids in the sand beds, the theoretical rate of straight downward travel at 2 gal. per square foot per minte would be approximately 0.67 ft. per minute. This is assuming no air present. With the voids three-fourths filled with air in the section where air is present, the theoretical rate would be close to 2.7 ft. per minute. It of course is evident that the rate of flow is quite variable, depending upon the resistance to the flow. With the zone of entrapped air 0.2 ft. in thickness, we can assume that there are several seconds in which the water is in contact with or in close proximity to an air surface. If the liquid surface approaches that of a falling drop, the several seconds is sufficient time for the liquid in very thin streams and films to release practically all its supersaturation. This is assuming the rate of escape of gases is about the same as the rate

TABLE II.—THE COEFFICIENT KL FILM THICKNESS FOR VARIOUS CONDITIONS

R.P.M. of Stirrers, Etc.	Investigator	Gas	K_L	Film Thickness in Centimeters
At rest	Adeney and Becker	O_2, N_2	0.4	0.17
60	Davis	O_2	3.3	0.020
150	Becker	O_2, N_2	5.0	0.013
250	Bohr	CO_2	7.5	0.009
1,000	Becker	O_2, N_2	15.0	0.0045
Bubbles rising	Lewis and Whitman	CO_2	60.0	0.0011
Drops falling	Lewis and Whitman	CO_2	60.0	0.0011

of absorption, and there is sufficient evidence in the chemical literature to warrant such an assumption.

Factors Essential for Starting the Release of Air in Supersaturated Water.—Even though a liquid is greatly supersaturated with air it is not likely that gas bubbles will start forming within the liquid itself. In fact, so far as the writer knows it is impossible to start a bubble within a liquid. If a dry glass beaker is filled with water slightly supersaturated with air a number of air bubbles will form on the glass surface, but the beaker has been wet for several days no bubbles will form on the glass surface even though the water has considerable supersaturation of air. It is possible to produce a supersaturation in which bubbles will form on a surface that is continuously wet, as is the case of sand in a filter bed, but the supersaturation required is much greater than will likely occur in any filtration plant.

This is one of the reasons why there is very little escape of air from supersaturated water in the mixing and settling basins. If a small bubble is carried beneath the surface in settling basins where the water is supersaturated, and begins to enlarge, it quickly rises to the surface and escapes. As stated, new bubbles cannot start forming in the water. What the sand beds do is to hold the air bubbles so they will not escape into the air. The writer has shown[4] that very small bubbles require a greater supersaturation for them to increase in size than for larger bubbles by the fact that when a small air bubble and a large one are placed close together in water just slightly supersaturated with air the small bubble decreases in size by going into solution while the larger bubble increases in size. This may partially explain why a very great supersaturation is required for bubbles to start forming on a surface continuously under the water.

One thing is evident in the escape of air in sand beds, there must be some air present to start the escape. For a filter that has collected air in its previous run, all the air is not washed out and many small bubbles are left attached to the sand to start air escape as soon as the water passing through the sand becomes supersaturated due to the increase in loss of head. The curve in Fig. 3 shows that the first point of supersaturation after the water reaches the sand level is near the surface of the sand. This perhaps is where most of the bubbles which are not washed away during the washing period are concentrated. A sand grain with a bubble attached is easier to lift by the wash water and it most likely will remain at or near the surface of the sand when the sand settles back after washing. The writer has observed this very condition many times in glass tube filters. In some instances the adhering bubble is large enough to carry the sand grain away with it in the wash water.

Sand Loss Due to Air Collecting in Sand Beds.—Many may not be aware that there is considerable loss of sand in washing an air-bound filter. Every filter operator is familiar with the unsightly foam that collects on the surface of the water, but they probably do not realize how much sand it contains. The writer has made measurements of the amount of sand carried away with the foam. Table III gives the results of several tests made a few years ago.

The diameter of the sand washed away varied from 0.34 mm. to 0.94 mm. in diameter. As only one sample was measured when ferrous sulfate was used to coagulate the water, the volume of sand washed away with the foam as given in the table should not be taken as typical of this treatment. When we see the foam collect 1 to 2 in. in thickness each time a filter with air in it is washed, it is evident that the sand loss will be great within the course of a year should there be air-binding all the time.

It may seem unusual for air bubbles to adhere to sand so toughly the washing will not knock it loose. The reason for this may be that the surface film around the bubble is toughly formed due to coagulated matter filtered from the water getting into the film, and during washing some of the sand grains themselves may be forced into this film. If one will watch the washing of air-bound glass tube filters they will become aware that some of the bubbles cling to the sand quite firmly. No one need expect to see nearly every sand grain with a bubble attached. Only a very small percentage of the grains will be found with attached bubbles, but there are enough to cause some loss of sand each time the filter is washed when air has collected in it. Also there will be enough of the attached bubbles that are not washed away to furnish the necessary air surface to start the escape of air as soon after washing the filter as the water passing by the bubbles become supersaturated due to the decreased pressure as the loss of head increases.

Slight Supersaturation May Not Cause the Release of Air.—Rain water should be saturated with air and the water in most flowing streams should be nearly saturated with air all the time, yet many filtration plants taking water from running streams are not troubled very much from air-binding. A condition might be assumed that very likely is typical of a number of plants. The top of the sand is about 5 ft. below the water surface, and the water has an amount of air in it that will require 1 ft. of suction from atmospheric pressure to make it become just saturated with air. This is equivalent to 1 ft. of head. With 1 ft. initial loss of head when the filter is put into operation after washing, perhaps 6 in. of this loss can be assumed to be in the top 2 in. of sand. This will mean that the total loss of head on the filter will have to increase to about 6.5 ft. before the water just becomes saturated with air in any part of the bed. If the filter is washed at a loss of head from 8 to 8.5 ft., only about 2 ft. of suction develops at the point of maximum suction.

During the period while there is pressure on the water in the sand and the water is just saturated with air at atmospheric pressure, the water beneath the surface will be under-saturated with air and there will be a tendency for the entrapped bubbles, if there are any, to go into solution. This pressure may be sufficient in many waters to dissolve all air bubbles before the loss of head on the filters reached the point where saturation equilibrium is produced. Air bubbles incased in a film containing suspended matter do not go into solution very rapidly, and it may require fairly long filter runs to give time for such bubbles to go into solution.

Thus it might be said that the average rapid sand filter starts off with a tendency to dissolve any air bub-

TABLE III—VOLUME OF SAND IN FOAM PRODUCED BY WASHING AIR-BOUND FILTERS

Coagulant	Approximate Age of Foam Before Collecting	CC. of Sand in 2,000 CC. of Foam	Per Cent Volume of the Foam
Aluminum sulfate	6 hours	6.0	0.30
Aluminum sulfate	7 hours	8.0	0.40
Aluminum sulfate	2 minutes	2.0	0.10
Aluminum sulfate	2 minutes	3.0	0.15
Aluminum sulfate	2 hours	2.6	0.13
Ferrous sulfate	2 minutes	0.05	0.0025
Aluminum sulfate	2 minutes	0.3	0.015
Aluminum sulfate	2 hours	2.5	0.125
Aluminum sulfate	10 hours	4.5	0.225
Aluminum sulfate	2 minutes	5.5	0.275
Aluminum sulfate	2 minutes	3.0	0.15

bles that may be present either in the sand bed or the coagulated matter, and that most filters reach a point where the water is slightly supersaturated as it passes through the sand bed. The point of greatest supersaturation is near the surface of the sand. For the release of air to start, there must be some bubbles that do not entirely go into solution when the loss of head is low, or the coagulated matter must carry bubbles onto the sand.

Conclusions as to the Best Methods of Reducing Air-Binding.—For plants that are already constructed, it may not be practical to prevent air-binding at times. The filters may be washed at a lower loss of head and some of the trouble avoided, but when the runs are very short this is not always practical. If the trouble is due to air leaks in the suction of pumps, or other such causes, this may be avoided by preventing the air from getting into the water. In some instances the growth of algae in reservoirs may be lessened, which will reduce the tendency of the water to become supersaturated with oxygen. Algae probably are the cause of only a very small amount of air-binding.

It is believed that designing engineers should give more consideration to the elimination of air-binding troubles in their designs. Make the designs so there will be little or no tendency for the water to become warmer before it passes the filter beds. Also design the sand beds low enough below the water level so that there will be little or no negative head developed in the sand beds at the maximum loss of head. If it is not practical to prevent the water from reaching the filtration plant so supersaturated with air that the above precautions will not prevent the escape of air in the sand beds, most of the supersaturation may be eliminated by spraying the water into the air.

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Experiences at Cleveland with Bacterial Aftergrowths in Distribution Systems

To the Editor: In the October issue, Vol. LXXVII, No. 10, an article appeared on "Bacterial Aftergrowths in Water Distribution Systems" by Mr. John R. Baylis, associate editor.

In this article Mr. Baylis' findings confirmed the findings of the Cleveland Water Department; that is, that due to the accumulation of sediment in the pipe mains of the distribution system, the bacterial counts and B. coli increased materially. This sediment consists chiefly of dead micro-organisms.

In the city distribution system we have one open reservoir on the raw water supply, and two open reservoirs on the filtered water supply.

Some 20 years ago it was the practice, in the summer, of opening up fire hydrants on dead ends of the system to flush out the mains. In the fall of 1911 chlorine was adopted as a sterilizing agent, and mains were still flushed out at infrequent intervals.

It has been the practice for years of the City Health Department to take half a dozen or so samples each day on the distribution system. These samples invariably showed up worse than our plant effluents. In fact twice in the last ten years I have had to install temporary chlorine equipment at the open reservoirs to kill aftergrowths.

November first last year, we installed an ammonia equipment at the Division Ave. filtration plant, and January first, this year, one at the Baldwin filtration plant. The results this year, up to date, have shown residual chlorine in the water at the extreme ends of the distribution system, no B. coli, and extremely low bacterial counts. The water leaving the plants takes approximately five days to reach the ends of the distribution system, and some of the water passes through two open reservoirs.

In answer to Mr. Baylis' article I would say, where present systems have open reservoirs, and cannot be covered very easily, the use of ammonia with chlorine is the answer to the problem. In fact, even having no open reservoirs on the system, ammonia should be used with chlorine to prevent aftergrowths so as to keep the B. coli contents as low as that produced at the plant effluent.

Without the use of ammonia, chlorine residuals cannot be maintained, and if chlorine residuals are not maintained the water supplied to the public is not kept sterile.

The above information is a resumé of our conditions here in Cleveland, and I thought would be of interest as it gives the answer to Mr. Baylis' article; that is by the use of ammonia in connection with the water supply all the troubles in the distribution system are eliminated.

W. C. Lawrence,
Superintendent of Filtration, Division of Water and Heat, Department of Public Utilities, Cleveland, O.

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$400,000 Greek Contract Awarded Ulen & Co.

Announcement has been made by Ulen & Co., engineers, of New York, N. Y., and Lebanon, Ind., that they had obtained from the Greek government an additional contract to build a rapid sand filter system for the new Athens water supply at a cost of about $400,000. American equipment will be used. This additional work will give to Athens one of the most modern and complete water-supply system of any city in the world, with a daily supply of over 15 m. g.

The new work in Athens supplements the work already accomplished by Ulen & Co. The Marathon dam, faced with the Pentelikon marble, which was used by the Athenians to build the classic structures of the Acropolis, and the hundreds of miles of pipe that have been laid, as well as the reconstruction of the aqueduct built by the Roman emperor Hadrian in 130 A. D., are some of the features of the work which has aimed at an adequate water supply, something Athens has lacked for 2,500 years.

The Works Operator's Confidant

Why the Operator of Water Works or Sewage-Works Should Keep a Diary of Plant Doings

By MORRIS M. COHN
Sanitary and Testing Engineer, City of Schenectady, N. Y.

IN the office of a great executive of an equally great utility corporation, hangs a framed plaque that asks curtly, "What Are the Facts?" In brusqueness and in directness, this query is symbolic of the times. There is a desire to know the why and wherefore of things.

Since the water purification plant and the sewage treatment plant are true representatives of the age, it is but reasonable to discover that this fact-finding tendency has invaded the field of the works operator. No subject has received more attention, been discussed more exhaustively or written about more voluminously than the subject of the necessity for the maintenance of complete records of plant operation. It has been the object of investigation by every water-works and sewage-works organization worthy of its name. Committees have convened and resolved with whereas after whereas that operation records are essential.

Printers have grown rich turning out record forms that range in size from the small sheet to charts that cover the walls of many offices. Recording guage manufacturers have developed mechanisms with floats and diaphragms and ingenious helical springs to supply the ever-increasing demand. And the operator has become weary, working into the wee hours of the morning, filling in the blank spaces and running planimeters over the face of charts made by scores of recording pens. Indication that there has grown up a record structure that is most cumbersome and un-uniform comes to us in the movement now on foot to reduce records to some more simple basis that will result in figures comparable from plant to plant.

But the records that are being accumulated in every self-respecting works are as cold and bloodless as the plaque that hangs on the office wall. They are but the skeleton of plant activity, they have no soul. There is need for a record of accomplishment that expresses the human side of this intensely human phase of municipal government. The operator of sewage-works or water-works who is not keeping a diary of plant doings is missing an opportunity to inject life into his work and to give himself a great deal of pleasure.

Keeping a good diary is becoming a lost art. Only the great and near-great keep a record of daily accomplishments. If the plant is to be great or near-great, a diary is a necessity. The definition of a diary explains its scope. A diary is defined as a register of daily occurrences and duties, a book for daily memoranda. Thus defined, the task of keeping this human record becomes easy. Sit down for a few moments at the end of the day, think a little, and jot down the things that have been done at the works during that day, the things that are not covered by the record forms or interesting angles of things that might be expressed by figures or notations alone in the tabulations. The day shift has gone home, the laboratory staff has left for the night. A sort of quiet has settled over the office. No one will pop in to ask aquestion about how to do this or when to do that. Open the little red book that you have learned to know as your friend and jot down your own thoughts. Perhaps your men found a still-birth on the bar rack this morning or you discovered the first psychoda of the season flying around near the trickling filters. It is likely that a group of college students were down on an inspection trip today. You have just reached the decision that the experimental baffle you placed in your sedimentation basin is causing too much sediment to deposit over the far corner. A neighbor dropped down today and complimented you on the fact that he has never smelled a plant odor up the street leading to the works. The local newspaper has carried a story about the beauty of your grounds. The rain of last night got you out of bed when the emergency overflow in the diversion manhole failed to function. The gas-burner, connected to the gas collectors on your sludge digestion tank, backfired and blew out the safety relief diaphragm. That hydraulic packing that the purchasing agent bought for you last week is working splendidly on your centrifugal pumps. You just had word that the estimate board has vetoed your request for additional funds for structure painting. You must look into the leak that has developed in your wash-water storage tank. Such facts as these you can confide to your diary; it will never divulge a confidence.

You will find that keeping a diary will prove of much value to you. Retrospection is most revealing. When you sit down and review the accomplishments of the day, you will have ample opportunity to discover your errors of omission or commission. The conclusion you draw about the value of a certain piece of work that took practically your entire day will, when placed in writing, lead to a decision for change of procedure or justication of your methods instead of being passed over very lightly in your mind.

You can't write a dairy without thinking and what our plants need is more thought on the part of the men who shape their policies. You will find that you become more observant of operation details that you missed before. Report-writing becomes a pleasure when you can browse through your daily notes and get into the spirit you were originally in when you actually went through the period the report will cover. Your dairy will give you opportunity to blow off steam and vent some of the inward feelings that the poor plant operator often gets no opportunity to express.

Your diary, if it becomes a semi-official document, may become a real aid to the municipality. When you leave your position to accept another, your successor will find the plant diaries a veritable fountain of information and inspiration. He may himself enter into the spirit of accomplishment that your diary emanates. The blank page may become to him a challenge to do something worth writing about. The record of personal observations may even have legal value. The statement in the writer's diary that he had cautioned his night men to use care walking on the Imhoff tanks one sleety evening, resulted in the decision of the city to settle out of court a case involving a damage caused by a slippery pavement. Another time, the statement in the writer's diary that sewage flow conditions during a midnight storm were worse than he had ever seen was included in the record of the city's defense of a sewer-flooding claim. The Venturi meter at the pumping sta-

tion gave the cold blooded flow data but the personal diary notation lent comparative values to the formal record.

You visit one sewage-works or water-works and find there an efficient installation owned by the municipality and you inquire the name of the operator. You visit another installation that seems to exude the spirit of the operator in charge. This works is in charge of a man who is living his work—it has come to be known by the man's name. Mention the name of the city and you immediately bring to mind the man who has made that sewage or water plant what it is. The first plant is but so much piping and concrete. The latter plant seems to have a soul. There is no one thing more helpful in injecting this highly desirable attribute into a plant than the maintenance of a plant diary by the operator. The diary is not the important thing. It is but that it typifies the mentality that is being brought to the job of providing pure water to the community or safeguarding the health of the neighboring municipalities down the diluting stream.

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The Economics of Utility Rate Making

The basis of value for rate making is the value as between a willing purchaser and a willing seller, Nicholas S. Hill, Jr., of New York, president of the Hackensack Water Co. of Weehawken, N. J., declared in an address on "The Economics of Rate Making" at the annual meeting last month of the Pennsylvania Water Works Association at Atlantic City, N. J.

"The true present value for rate making," Mr. Hill said, "is the same as the value for purchase and sale. Utilities have not three or four values, one for the purpose of taxation, another for rate making, and another for purchase and sale. Such an assumption is not founded on reason or supported by law."

Public utilities have a duty to perform for the public in return for which they should receive fair compensation, Mr. Hill asserted. The utilities and the public, he pointed out, have such intimate business relations that a blow at either must seriously injure the other, and, though there have been errors and confusion on the part of both, the fact that the capital invested in utilities is largely the money of the people, and not necessarily that of a group or coterie, should not be lost sight of.

"The hard earned investments of the public should in all equity be safeguarded to prevent their loss by manipulation and to insure a fair return," he added. "A clear comprehension of this mutual relationship is needed on the part of both the utilities and the public. The idea that a utility is a private business enterprise is a popular fallacy.

"The property of such a concern may be privately owned, but the use to which it is put is public. In its use the public is vitally interested. It is therefore, essential that all men should be straight thinking and stand for fair dealing as between utilities and the public which they are established to serve.

"With this concept of the relationship between utilities and the public which they serve, it is obvious that if the public expects efficient service it must allow utilities to earn an income sufficient to enable them to give good service. In order that this income may be sufficient to give good service the utility must be allowed:

"First, to earn a return sufficient to pay interest and dividends to its bond and stockholders and to have a sufficient surplus to acquire new capital from time to time as the requirements of the service make necessary.

"Second, to earn an income sufficient to cover operating and maintenance expenses, taxes and a proper annual reserve against depreciation of its property and plant.

"The economics of rate making, therefore, are based primarily upon securing an income sufficient to meet the requirements. The establishment of the fair value of the property upon which a fair return is to be estimated is but one element of the problem of determining fair income.

"The courts have generally held that the value of the property to be determined is its fair value at the time when the inquiry is made regarding the rates, and that if the property which properly enters into consideration of rates has increased in value since it was acquired the corporation owning it is entitled to the benefit of such increase.

"So far as water works are concerned, the latest decision of the Supreme Court which holds this view is in the case of McCardle vs. the Indianapolis Water Co., in which there is a clear enunciation of the principle. Many utilities are inclined to interpret this rule as meaning that the cost of reproduction new less depreciation measures value. I have never been able to find a single decision of any court making such a rule, the Indianapolis decision included.

"If the public on the one hand is expected to provide a fair return on the fair value of the used and useful property, it cannot on the other hand be expected to recoup losses resulting from errors in judgment, waste, extravagance and speculation on the part of the owners of an overbuilt property.

"However this may be, it does not justify setting up a hokus pokus reproduction estimate by eliminating items of value from the total and thereby confuse the ascertainment of true value.

"The only way true value may be reached is by reproducing the existing plant item by item as is and to reason a priori from this in what manner reproduction cost must be modified. It is highly improper and confusing to lop off portions of a plant, substitute other materials for the materials actually used, and arrive at a result which indicates nothing and gives no basis for the exercise of judgment.

"Few people recognize the close inter-relationship between value and income. To maintain a fair relationship between the owner of a property and the owner of money both must be considered, but in view of the fact that rates for money are not fixed by the state but by the law of supply and demand, the inquiry must be limited to ascertaining the fair rate of return in the contemporary money market on the fair value of the property at the time of its appraisal."

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North Dakota Water Works and Sewerage Operators to Meet in December

The second annual meeting of the North Dakota Water and Sewage Works Conference will be held at Grand Forks on Dec. 8, 9 and 10. A feature of this year's meeting will be a short school in conjunction with the School of Engineering at the State University. A short course will cover topics of special interest to water and sewage works operators as well as consulting engineers. A number of papers covering various phases of water, water supply and sewage disposal problems have also been arranged. The officers of this organization are: E. J. Thomas, Minot, president; William Yegen, Bismarck, vice-president; A. L. Bavone, Bismarck, secretary-treasurer.

Why It Rains More During the Early Morning and Late Afternoon

By HALBERT P. GILLETTE

BOOKS on meteorology have frequently called attention to a prevalent 12-hour cycle in barometric pressure that is concurrent with a similar cycle in electric potential gradients in the atmosphere. In his "Physics of the Air" Humphreys says: "It has been known now for 2.5 centuries that there are more or less regular daily variations in the barometer, culminating in two maxima and two minima during the course of 24 hours. * * * * Since Beal's discovery (1664) the same observation has been made and puzzled over at every station at which pressure records were kept and studied, but without success in finding for it any adequate physical explanation."

The reason for failure to find an explanation long ago lies in the fact that the electron was not discovered until about 30 years ago, and that the existence of a shell of electrons around the earth was not suspected until several years later. I refer to the "Heaviside layer" of electrons, which reflects radio waves.

On Sept. 12, 1930, American newspapers published abstracts of a scientific paper read the day before by Marconi in Italy, in which he advanced the theory that several distinct shells of electrons surround the earth. I had previously come to the same conclusion, and had written three articles, one of which was then in type, expounding a multiple electron shell theory. I had also given an interview to a California paper, in which I had said that "it is reasonable to suppose that, like the earth, the sun is surrounded by shells of electrons." That interview was published on the same day that Marconi's theory of multiple electron shells was first published in American newspapers. "The Foothill Review" (South Pasadena, Calif.), of Sept. 12, contains the following interview that I had given several days before.

"About two hours before sunrise the barometer usually falls slightly and two hours before sunset it repeats this process. When the barometer falls rain is most apt to occur.

"This twelve-hour period between low barometric pressures is quite like the 12-hour period between tides in the ocean. However, oceanic tides are due mainly to the moon's gravitative pull and it has been found that the moon produces almost inappreciable tides in the atmosphere. It is clear, then, that some other force than gravitation causes the fall of the barometer every twelve hours. I attribute this phenomenon to solar magnetic force.

"The earth is known to be surrounded by a shell of electrons. Electrons are particles of matter smaller than atoms and they are always charged with electricity. When in motion an electron has magnetic properties. Two electrons moving in the same direction attract one another. Two electrons moving in opposite directions repel one another.

"It is known that the sun's atmosphere contains electrons, so it is reasonable to suppose that, like the earth, the sun is surrounded by shells of electrons. What magnetic effect would a solar shell of electrons have upon a terrestrial shell of electrons?

"The answer is easy if it is remembered that both the sun and earth are rotating in the same direction, counter clockwise,around their axes.

"In consequence of this axial rotation, the electron shells in the solar and terrestrial atmosphere are also rotating, and the electrons consequently behave like magnets.

"The terrestrial electrons nearest the sun repel the solar electrons nearest the earth, because they are moving in opposite directions. On the other hand, the terrestrial electrons farthest from the sun are attracted by the solar electrons nearest the earth, because they are moving in the same direction. Consequently a terrestrial electron shell is squeezed by these two forces, and is brought nearer to the earth along the central meridian or plane that passes through the centers of the earth and the sun. This squeeze causes the electron shell to bulge out along a plane perpendicular to the central meridian. Thus we get a magnetic tidal wave in the electron shell, very similar to the gravitative wave in the ocean.

"A little consideration shows that the bulge in the electron shell would be greatest at 6 a. m. and 6 p. m. were there no friction or inertia to retard this magnetic tide. Any such resistance would cause the tidal bulge to come earlier, and as a matter of fact it comes two hours earlier.

"When an electron shell thus bulges away from the earth it lifts air with it and so reduces the pressure on the air below, causing the barometer to fall. But the lifting of the air brings it into a cooler region, which tends to precipitate some of its moisture. This explains the tendency toward greater rainfall at 4 a. m. and 4 p. m.

"After arriving at this semi-durinal explanation of barometric lows, it occurred to me that earthquakes should be more numerous about 4 a. m. and 4 p. m. I investigated some 200 quakes in Alaska and found that twenty-two per cent of the quakes occurred between 3 o'clock and 7 o'clock in the morning and twenty-four per cent between 8 and 12 p. m. In other words in one-third of the day nearly one-half the earthquakes occurred. There were 40 per cent more quakes during the hour from 4 to 5 than during the average hour.

"Thus my theory as to earthquakes was sustained by the facts, and, in addition, I found that the period of 8 to 12 p. m. is abnormally quaky. This led to an investigation of the reason why that period is so quaky, but as the reason is somewhat difficult to present without a drawing, I will not attempt to give it.

"Alaska is an exceedingly quaky region because it is so near the center of the great molten whirl that uplifted the Aleutian Islands and created that great chain of volcanoes many of which are still active. California has no volcano that has shown activity since Mount Lassen erupted in 1851."

To the foregoing interview a few allied facts may be added. In the "Monthly Weather Review," September, 1928, J. F. Voorhees published the results of his analysis of the hourly precipitation at Knoxville, Tenn., during the years 1898 to 1924, inclusive. The rainfall curves of average hourly rainfall show two maxima, one at

5 a. m. and the other at 6 p. m. The two minima are at about noon and midnight. The average hourly rain from 4 to 6 a. m. was 25 per cent in excess of the average hourly rain at midnight. The average hourly rain from 3 to 6 p. m. was about 8 per cent in excess of the average from 4 to 6 a. m., or 35 per cent in excess of that at midnight. The average hourly rain at noon was 7 per cent in excess of that at midnight. The rainfall from 6 a. m. to 6 p. m. was 51.5 per cent of the total for the 24 hrs. From these percentages it is evident that the semidiurnal barometric tide is a very important factor in rainfall in certain localities. Hence it follows that the electromagnetic forces that presumably cause this tide are very important factors in causing rainfall.

Huntington, in "Earth and Sun" and in "Climate Changes," states that while he is convinced that electricity plays a part in causing rainfall, he is equally convinced that it is a very minor part. And he points to the "march of the seasons" as evidence that the quantity of heat received by the earth at different latitudes is the major factor. But this latter argument seems defective, for rainfall is not primarily a function of temperature, else all places in the same latitude would have rainy seasons at about the same time. California's rainiest month is January, whereas that of Texas is July, when California gets almost no rain, yet they are in nearly the same latitudes. So many other similar differences exist in the world that it is clear that the "march of the seasons" as to rainfall is often quite different from the "march of the seasons" as to temperature.

While it was long ago discovered that the 12-hour cycle of barometric changes is concurrent with a 12-hour cycle in the electric potential gradient in the lower air, no adequate reason for this relationship had been suggested. An adequate reason is now supplied by the theory that the electron shells around the earth are lifted twice a day to a maximum height, like the ocean tides. This semidiurnal lifting is effected, I believe, by the electron shells that surround the sun. When a terrestrial shell of electrons bulges away from the earth, the potential gradient in the lower atmosphere should be lowered, and this is evidently what occurs.

In addition to causing increased precipitation by lifting the electron shells where clouds exist, the bulging up of those shells undoubtedly causes a flow of electrons from the earth into the air. Such a flow would increase the intensity and magnitude of the electron whirls in the atmosphere. I regard those electron whirls as the cause of cyclonic storms. Cyclonic storms tend to migrate, and thus serve to carry moist ocean air inland where some of the moisture is precipitated.

Condensation of moisture is known to be effected by electrons. Add to this the electron-whirls as a cause of cyclonic air-whirls that spiral upward; and to that add the electron shells that are caused to rise and fall periodically by solar and planetary magnetic forces, and there results an electron theory of rainfall that explains most of the enigmas of that phenomenon.

How New Water Works Reduce Fire Insurance Rates.—The town of Hartford, Kan., installed a $40,000 water works in the spring of 1930. Fire insurance rates have now been reduced from 15 to 60 per cent on mercantile establishments and 21½ per cent on dwellings, or an average of from 25 to 30 per cent on property within the city limits, as a result.

Coagulation Conditions and Bacterial Efficiency of Preliminary Water Treatment

The United States Public Health Service has recently announced the results of certain experimental studies relating to coagulation conditions and bacterial efficiency of preliminary water treatment. The studies recorded in this report are concerned with the effects of (a) the period of sedimentation, (b) the method of applying coagulant to the raw water, (c) the hydrogen ion concentration of the coagulation reaction, and (d) the density of coagulant added to the raw water, on the bacterial efficiency of coagulation-sedimentation as a preparatory treatment of water for rapid sand filtration and, incidentally, on the efficiency of the entire process of rapid sand filtration.

The experiments were carried out during portions of the three years, 1926, 1927, and 1928, at a fully equipped experimental rapid sand water filtration plant of 160,000 gal. daily capacity, designed to typify, as nearly as possible, current large-scale practice in this process of water purification, but with certain additional features incorporated in the plant for experimental purposes.

The results of the study yielded the following main conclusions:

(1) Substantial gains in the bacterial efficiency of coagulation-sedimentation resulted from prolongation of the nominal sedimentation period up to 8 or 9 hours, and measurable gains with periods up to 12 hours.

(2) Variations in the hydrogen ion concentration in the coagulation reaction from 5.6 to 6.9 produced little effect on the efficiency of coagulation-sedimentation. The efficiency became sharply diminished, however, with hydrogen ion concentration values exceeding 7.0 and slightly improved with hydrogen ion concentration values approaching 5.5.

(3) The bacterial efficiency of double-stage coagulation, with two separate stages of sedimentation, was consistently greater than that of single-stage coagulation with one stage of sedimentation. The observations indicated, however, that with the same total amount of coagulant and the same total period of sedimentation, little if any difference was observable between the results shown by double-stage and single-stage coagulation when carried out in conjunction with two separate states of sedimentation.

(4) A fairly consistent relation was shown between the amounts of coagulant added to the raw water and the resulting bacterial efficiency, both of coagulation-sedimentation and of this state in conjunction with filtration. This relationship was found to hold irrespective of raw-water turbidity or bacterial content, though it was more apparent when the turbidity and bacterial numbers were higher. Measurable gains in efficiency were shown with increases in coagulant density ranging up to 5 grains per gallon.

The general conclusion reached from the foregoing series of experiments was that the bacterial efficiency of rapid sand filtration processes can be increased very materially by means of longer periods of sedimentation and larger amounts of coagulant than ordinarily are used in current water purification practice. The economical limit of sedimentation appears to be reached some where between 8 and 12 hours, with little gain in efficiency beyond the upper limit of time stated.

Problems of the Distribution System

Tests in and Around the Pumping Station—Flushing Dead Ends and Low Points—Suggestions for Laying Mains—Installing Service Connections

By WILLIAM J. GRAY

Engineer-Superintendent, Springfield City Water Co., Springfield, Mo.

A SUMMER of intense heat and dry weather like that of the present year, is one rarely to be forgotten on account of the problems of distribution it called forth. The range extends from the supply to the consumer, the reservoir to the house faucet. So I shall open the subject, starting at the point of delivery—the pumping station.

The first things which impress us as we enter the station are the pumps which deliver the water to the city. The question arises: Are the pumps up to their maximum efficiency? Its solution is a simple matter of calculation. Take, for example, electrically driven pumps. Let me briefly discuss the procedure of making the test.

Testing Electrically Driven Pumps.—We select a certain period of time and read the electric power meters, the Venturi meter, pressure and clear well depths simultaneously every 10 minutes during the period, which is usually 30 minutes. From the manufacturer we determine the rated efficiency of the electric motor. Applying this to the power consumed, we get the amount of power delivered to the motor, known as the input power. We then determine the output power by taking the number of gallons delivered in the period, and by applying it to the head or delivery pressure, we determine the work done. Concerting this into horsepower and then into its electrical equivalent of kilowatts and dividing this result by the input power we determine the efficiency of the pumps. In many cases we will be surprised if we have never tested the pumps. The falling off may be from 2 to 10 per cent. Evaluating the loss in dollars and cents we see the value of having pumps up to their rated efficiency.

At Springfield we had this problem on our three pumps of 3, 4 and 5 m.g. capacities. We make it a rule at our station to determine the efficiency of these pumps yearly, and when the drop in the efficiency is noted, we promptly overhaul the pumps, putting in new bearings, liners and remove a large amount of corrosion. By making the inside of the surface smooth and covering it with a rust inhibitive and waterproof paint, we developed efficiency better than we expected, slightly in advance of the manufacturer's rating made 15 years ago when the pumps were installed.

Supplying Station with Surface Water.—Another interesting problem at the station is to supply the station with service water for use in cooling the bearings, laboratory work and other purposes. Heretofore, this water was taken off the high pressure lines through pressure reducing valves. The idea came to us to take water for this use from the first stage of the pumps. On two stage pumps, the pressure in the first stage is about one-half of the finished pressure of the second stage. Over a long period this makes a considerable saving in power loss.

The next important phase at the pumping station, that is, stations which are equipped with filters, is the testing of the filters. This should be done in the early spring so that if any are found below efficiency they may be overhauled before heavy draft conditions occur.

Another important step is to test, carefully, the valves on the various lines around the station—especially the transmission lines. This is very important because of the errors which creep in for no known reasons, such as slightly closed valves, unnecessary check valves, broken stems, badly corroded gates and other troubles. This applies, also, to the supply mains coming into the station.

Preparing for Breaks.—I think one of the most important safeguards, I should almost call it the foremost. is to have on hand a good supply of the various fittings and pipe which are used in the distribution system. In a growing city, breaks of more or less serious nature are liable to occur at any time. I cite one instance.

One day in August, 1929, when the thermometer was soaring upwards and the draft on us for water was doubling normal demand, suddenly one of our transmission mains, 18 in. in diameter, was broken by a contractor's heavy grader. The caterpillar tread of the grader crushed an air valve on the main and forced it with sufficient pressure to burst open the line. This main carried about 100 lb. pressure and you can imagine the fountain display we had before it was possible to shut off the lines. In less than five hours this main was repaired and back in service. This would not have been possible had it not been for the extra pipe and fittings sufficient to make the repairs.

Importance of Maps and Records.—Here let me add a few words, before going into other problems of the distribution system about the importance and value of maps and records giving completed details of the distribution system. The importance of these is often underestimated. This is false economy, because their worth is demonstrated many times during the year. They indirectly create a deeper interest and greater intelligence of all the employees of the company. They prevent gross errors of various kinds, and offer the only real intelligent solution of providing for the growth of the future.

Flushing of Dead Ends and Low Points.—Upon reaching the point of distribution in the city, the first thought that occurs: Are we giving attention to the actual quality of water which we are furnishing the city? Is the flushing of dead ends and low points in circulating mains carried on periodically during the year, especially during summer months?

The fact that the mains are gridironed so that a complete circulation is established is no evidence there is not a collection of sediment in the low points in the lines. At such locations and also at dead ends the water becomes foul rapidly in the summer season, and bacteria will thrive inside the mains under such conditions. We do most of our flushing from fire hydrants. On 2-in. lines where there are dead-ends we invariably install, at the end, a 1-in. curb stop with a riser pipe so placed inside of a valve box for the purpose of blowing out the main whenever necessary. Many conditions of unpleasant taste can be attributed to the fouling of water in the dead-ends and low points of circulating mains.

Points on Laying Mains.—Valuable information may, at all times, be given for the laying of water mains.

The breaks on the water mains may be caused by various reasons, but it is a very safe policy to give special attention to the support of the main. Is the bottom of the trench firm and solid, sufficient to carry, uniformly, the load? On pipe of over 12-ft. lengths, we invariably support the pipe at two points when lining up the pipe for pouring joints. These points are about 3 ft. back of the bell and spicket ends of the pipe.

Under railroad crossings it is safe to provide at least a minimum of 4 ft. cover on the main. Once when the ditch is made the fill material is in continual vibration when a train passes over the tracks and during freezing conditions this becomes a frozen, solid mass extending to the depth of the frost. This entire weight strikes the remaining fill in the ditch a heavy, uniformly distributed blow, as the train crosses the ditch line. If the main is not firmly embedded there will be a tendency to dislodge it and finally cause a leak which ultimately will lead to disaster if not found and repaired.

A striking example of this occurred in Springfield under one of the main lines of the Frisco railroad and if it had not been for the promptness of the water works foreman in responding to an early morning call, there would have been a wreck of a fast passenger train approaching the crossing at the time of the break in the main. Such lessons as this bring home a greater sense of responsibility on the water works superintendent and the foremen directing laying of mains.

It also should be remembered in the laying of mains where new paving is to be placed immediately afterwards that the backfill in the ditches gradually settles and throws its load on the main and also on the service, quite frequently causing a leak.

Installing Service Connections.—In this connection I might add that we tap our mains for water service on the side of the main 90 degrees from the top point.

We also put a slight bend in the goose neck, making it in a horizontal plane, this gives ample protection for expansion and contraction, thereby relieving the hazard and danger experienced on the old style, tapping of the main 45 degrees and putting the bend on the goose neck on a vertical plane.

Meter Testing, Setting and Reading.—Keeping meters in a good state of repairs is a very important step. At Springfield we test all outgoing and incoming meters. This assures us of good registration and a high degree of efficiency of the meters out in service. Fine stream management in meters is not so desirable for the coffers

McDaniel Lake, the New Water Supply of the Springfield, Mo. Water Works Co.

The New 1,125,000,000-Gal. Water Supply of Springfield, Mo.

of the water department as is accurate measurement of large streams and the capacities of meters to permit large flows to the average consumer.

Setting the meter at the curb has a decided advantage. With a safe meter box which can be opened quickly it means dollars and cents to the water department.

We have meter readers in our service who have read over five hundred meters in one day with only one or two re-reads. Half of this number could not have been accomplished if the meters were in the basements. We have also found that by offering prizes to meter readers we have brought about an increase in efficiency of almost 100 per cent with a corresponding saving in cost.

Acknowledgment.—The foregoing is a paper presented Oct. 23 at the 6th annual Missouri Water and Sewerage Conference.

Tank Manufacturer Sponsors Competition for Best Elevated Tank Design

The Chicago Bridge & Iron Works, manufacturers of steel tanks and steel plate work, is sponsoring a competition for improved design in elevated steel tanks. Four thousand dollars in prizes are being offered for the best eight renderings, divided as follows:

First Prize	$2,000.00
Second Prize	1,000.00
Third Prize	500.00
And 5 Honorable Mention Prizes of, each	100.00

Entries in the competition will consist of two drawings of a typical elevated steel tank with a nominal capacity of 200,000 gal., a height to top of approximately 110 ft., a height to bottom of not less than 85 ft., and a riser not less than 5 ft. in diameter.

One drawing will include a direct elevation and two horizontal sections or plans ¼-in. scale. The other will be a perspective drawing to the same scale.

The entries will be received anonymously, displayed in a suitable room in an impartial manner and judged by a jury of award consisting of Mr. Howard Cheney, president of the Chicago Chapter of the A. I. A., Mr. R. W. Zimmerman, architect of Chicago, and Mr. George T. Horton, president of the Chicago Bridge & Iron Works.

Mr. Albert M. Saxe of 430 North Michigan Ave., Chicago, Ill., has been appointed professional advisor for the competition and will handle all communications regarding it. A brochure giving complete details of the competition may be secured by addressing Mr. Saxe.

This competition is open to architects, engineers and draughtsmen all over the world. Applications for entry will be received by the professional advisor (Mr. Albert M. Saxe) until Dec. 1, 1930. The contest closes on March 1, 1931.

Foaming in Imhoff Tanks

Stages Involved in Digestion—Causes of Foaming—Preventive Methods—Corrective Methods —Experiences in Prevention of Foaming

By GEORGE S. RUSSELL
Russell & Axon, Consulting Engineers, St. Louis, Mo.

THE phenomenon known as foaming in Imhoff tanks has been and still is a matter for considerable study and investigation. There is no uniformity in Imhoff tank operating conditions. At different sewage works the composition of the sewage varies widely and even at the same plant there may be seasonal, daily and even hourly variations. Methods for reduction of foaming employed in one digestion chamber failed when applied to another handling the same sewage under presumably the same conditions. It is evident then that there are so many contributing factors and the processes involved are so complex that the determination of basic causes is difficult and there is great need for further study. At the present time we have to be content with stating certain causes which seem to promote or accentuate foaming without definitely knowing the fundamental cause.

Stages Involved in Digestion.—Rudolfs has suggested that the stages involved in the process of digestion be grouped for practical purposes as follows:

1. A period of intensive acid production during the decomposition of the soluble carbon compounds and the breaking down of cellulose. Organic acids are formed at a greater rate than they are broken down, resulting in a low pH and a large amount of carbon dioxide being produced.

2. A period of acid regression and acid digestion when the organic acids are decomposed at a greater rate than they are formed and the accumulative material decreases. The pH approximates neutrality during this period.

3. The period of intensive digestion of more resistent materials during which time biological balance is being established. A greater production of methans and a pH above neutrality characterizes this stage.

Causes of Foaming.—If the processes of digestion do not proceed beyond the first stage, foaming may result and the sludge will be poorly digested.

It has been stated by Chester Cohen that "Foaming conditions are largely due to abnormal physico-chemical conditions of the material in the gas vents in combination with the quantity and quality of gas resulting from certain predominating types of biological organisms or bacteria and possibly both."

With regard to the necessity for quick contact of the new sludge entering the digestion chamber through the slot in the sedimentation compartment with the old ripened sludge, it may be stated that hours of delay at this stage may be reckoned as days so far as the retarding of the digestion process is concerned. This is because the rapid production of organic acids in the first stage of digestion, as outlined above, produces inhibiting effects which bring the whole process to a temporary halt unless the acid is neutralized by either mixing the new organic deposits from the sedimentation chamber with the old alkaline sludge or by mixing chemicals such as lime to these organic solids in order to raise the pH value.

It is our belief that the rising gas filled scum requires a certain minimum of surface area in order to release its gas and that this area is not sufficient in the ordinary types of Imhoff tanks, hence the raw sludge settling through the slot is held up by this gas-filled scum which rises from below and does not come directly in contact with the digested sludge at the bottom. This action tends to keep this new sludge in the first stage and this is the basic cause of foaming.

The fact that sludge in the first stage of digestion needs to be mixed with old alkaline sludge in order that the processes of digestion may not be retarded explans why foaming is prevalent during the ripening process when an Imhoff tank is first put into operation or after shut down of the plant for repairs, and the rapid production of acid in this first stage has given rise to the statement that foaming is due to acidity. When a tank is first put into operation or after a shut down for repairs, because there is no ripened sludge to raise the pH value, lime should be added for this purpose in order to carry the digestion process beyond the first stage. Where the tank has been in operation for some time, some method of reducing the flow of gas or mixing the contents is necessary so that the alkaline ripened sludge may be brought into contact with the newer sludge in the first stage of digestion. By doing this the inhibiting effects of the rapid production of organic acids in the first stage will not bring the process of digestion to a temporary halt.

Too violent boiling or foaming is not likely to occur when the area for the escape of gas has been made large and the gas is not confined. It might be pointed out here in this connection that well digested sludge rapidly loses its inoculating capacity so that large quantities of old, well digested sludge may actually contribute to foaming when a tank is placed in operation after being out of service for a few months and the ripened sludge has been left in the digestion compartment with the idea of eliminating the troubles incident to breaking in a new tank. It may also be seen that too frequent drawings of sludge, particularly when the amount of well digested sludge left in the tank is not in sufficient proportion to neutralize the effect of the freshly deposited sludge, may give the same results as outlined above.

Preventive Methods.—The idea prevalent in small municipalities that an Imhoff tank operates automatically is a fallacy. Satisfactory operation requires intelligent and competent supervision. The operator should at least have a definite understanding of the purposes of the tank and the fundamental principles involved, and be conscientious in carrying out these purposes and principles. Even well designed and properly operated tanks may at times present difficulties which will tax the ingenuity of the most skillful operator, but a poorly designed tank may be made to give fairly satisfactory results by intelligent operation, and conversely, a well designed tank may utterly fail to produce satisfactory results if improperly handled.

In order to prevent the formation of scum in the sedimentation compartment, squeegees should be used upon the sloping baffles so as to remove all solid ma-

terials which may adhere. It is absolutely essential that these baffles and the slot below them shall be kept clean so that septic action does not occur in the sedimentation compartment. This may be necessary as often as once or twice a week. Material floating on the surface of the sedimentation chamber should, of course, be removed from the tank or deposited in the digestion chamber through the gas vents. No sludge should be removed except for the talking of samples until the tank is well ripened. It is well to provide for reversal of flow in Imhoff tanks so that the solids may be more evenly distributed throughout the digestion compartment. This is especially true in long tanks. The ripening of the sludge can be determined by examination, and under no circumstances should all of the sludge be removed at any time except during a severe case of foaming. Any accumulation of scum in the gas vents should be broken up and pushed down into the digestion chamber. If it is possible this is best done with the stream from a fire hose which may draw sewage pumped from the digestion tank itself.

When the raw sewage shows considerable acidity for short periods, it may be advisable to circulate the sludge in the digestion chamber by pumping from the bottom of this compartment and discharging this ripened sludge into the gas vents.

Corrective Methods.—A removal of some of the ripened sludge may reduce or stop the foaming. If the tank has recently been put into operation, the addition of lime to the digestion compartment may prove satisfactory. At this stage the amount of lime necessary can be found by taking a sample of the sludge liquor and titrating to a pH value of 7.0 and from this data, knowing the total volume of sludge liquor, the amount of hydrated lime necessary to neutralize it can be calculated. When a large quantity of sludge is in the tank, the quantities of lime necessary to produce satisfactory results is prohibitive.

Where the addition of lime has had little result in the correction of foaming, it has been found that although the pH value is raised shortly after this addition, it drops again rather rapidly and in a short time it is back below the neutral value again.

In our opinion the best method of addition of lime is by the use of some simple feed apparatus depositing the lime into a trough and by pumping sludge from the bottom of the tank into this trough and emptying the mixture into the gas vents. In a few cases, however, the addition of lime has been found to actually increase the foaming and it may be necessary to draw off all the sludge and start the tank anew adding lime in small quantities and at frequent intervals in order to keep the pH value above the neutral point.

Experiences in Prevention of Foaming.—In Flint, Mich., experiments seemed to indicate that a small amount of sludge circulation by air is helpful in promoting balanced digestion, principally by preventing heavy scum formation. Our observation, as indicated previously in this article, is that any type of recirculation by breaking up the sludge and the freeing of gas may serve to keep foaming under control by rapidly bringing the sludge to a more balanced state.

In Austin, Tex., it was fairly well established that relatively small chlorine dosages (6 p.p.m.) applied to the sewage entering the tank reduced the tendency to foam and produced a more satisfactory tank affluent. Dosages as low as 3 p.p.m. reduced the foaming noticeably. It was noticed that if odor control was not a factor the dosage of 3 p.p.m. might be concentrated over the period from 8:00 A. M. to 5:00 P. M. with approximately the same results as if applied throughout the 24 hour period.

In Germany, there has been developed a new type of tank with a submerged sedimentation compartment. This type of tank by bringing the level of the sewage in the digestion chamber above the top of the sedimentation compartment, increases the scum area and makes easier the release of gas. The tank has a sloping roof on the sedimentation section with a slot at the top so as to allow the escape of floating solids. Experiences, during the last few years, seem to indicate that foaming does not occur in this type of tank.

Conclusions.—The successful operation of the latter type of tank would seem to indicate that the prevention of foaming as outlined in this article is based on the provision of enough scum area to provide for the escape of gas. This is also borne out by our observations which indicate that foaming is most prevalent where tanks are designed with a small proportion of scum area which is particularly indicated in tanks of the multiple type where chimneys are used for gas vents. While, as has been indicated, it would seem that we cannot arrive at definite conclusions at the present time, we deem it advisable that future designs show an increased scum area, and that, in tanks already constructed, this deficiency may be to some extent provided for by corrective measures which tend to release the accumulations of gas as quickly as possible and to bring in contact the raw acid sludge with the ripened digested sludge so that the digestive process may not be interfered with but carried to their ultimate conclusion.

Acknowledgment.—The above is a paper presented Oct. 24 at the 6th annual Missouri Water and Sewerage Conference.

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Annual Convention North Carolina Water Works and Sewage Works Associations

The 10th annual convention of the North Carolina Section, American Water Works Association and the 8th annual meeting of the North Carolina Sewage Works Association were held jointly at the Skyland Hotel, Hendersonville, N. C., on Oct. 13, 14 and 15. Sixteen states of the south, east and middle west, and one foreign country were represented at the meeting. The registration reached 236, of whom 131 were city officials, superintendents, plant operators, engineers and public health officials actively engaged in the planning, design, construction, operation and financing of water and sewage works; 61 were commercial representatives of manufacturers and dealers in water works and sewerage equipment and supplies; nine were special representatives of professional journals and the press; and 35 were ladies and other visitors. The exhibits of about 30 firms were attractively arranged in the lobby and adjoining rooms of the hotel, and, as usual, constituted one of the most attractive features of the convention.

At the joint business meeting of the two associations Greensboro was selected as the next convention city, and the dates fixed as Nov. 2, 3 and 4, 1931. The officers elected for the coming year are as follows:

President, A. S. Lyon, Rocky Mount, N. C.; vice-president, Geo. S. Moore, Albemarle, N. C.; secretary-treasurer, H. G. Baity, Chapel Hill, N. C.; editor, E. G. McConnell, Charlotte, N. C.; representative on board of directors, American Water Works Association, W. E. Vest, Charlotte, N. C.; representatives on board of control, Federation of Sewage Works Associations, H. E. Miller, Raleigh, N. C., and W. M. Piatt, Durham, N. C.; chairman of nominating committee, J. O. Craig, Salisbury, N. C.

Stand-by Charges for Water Works

What Has Been Accomplished in Arriving at the Cost of and Fixing a Charge for Fire Service Furnished to Municipalities

By C. E. THATCHER

Manager of Commercial Department, East Bay Municipal Utility District, Oakland, Calif.

THE subject of this paper will first be defined. The term, "Stand-by Charges for Water Works," shall be understood to mean a charge for "readiness to serve" or "stand-by" service available to municipalities for fire purposes.

Fire Purpose Supply a Distinct Service.—If the operation of a water works was confined only to the rendering of service to domestic and industrial consumers, the transmission and distribution mains and other equipment required for such service would be smaller in size than that required to provide additional service to municipalities for fire purposes. It seems reasonable to assume, then, that anyone familiar with water works operation can and should appreciate the fact that in providing equipment sufficient in size to render additional service to a municipality for fire purposes is the rendering of a service that should be classed as distinct and separate from other services and the cost and charge for such should not be combined with the cost and charge for any other service. Those who receive the benefit of the service should pay for it. The cost of this special service is, it is thought, a just and proper charge against the municipalities.

A municipality is supported by its tax payers. Therefore, the tax payers should pay for this "readiness to serve" or "stand-by" service. For example: The tenant in a rented house should only pay for the cost of water served to him for domestic use. The owner of the house, the tax payer, should pay the municipality for the protection given to the house against fire. Further, the large area in cities upon which stands immense buildings and other structures must have fire protection. To afford such protection requires the installation by water works of facilities greater in size than would ordinarily be installed for domestic and industrial use only. It follows then that the municipality should pay the water utility for the additional service that it is asked to provide and secure the amount required to pay for such service by a tax levy. The regular consumers of water should be relieved of the burden of paying the cost of this class of service.

Difficult to Distribute Burden Equitably.—It should be appreciated how difficult it is to distribute equitably the burden of the cost of water served to each class of consumers. There appears to be no recognized authority on distribution of fire service cost. It is an innovation in cost of service distribution and rate making, in water works management, that can be classed as new. Whenever anything new is introduced for use, either a service or a commodity, someone or some agency has to carry on the experimental work and do the pioneering.

A few years ago the Railroad Commission of the State of Wisconsin came to the front and strongly advocated the establishing of a charge against municipalities for the fire service facilities and classed such as a "readiness to serve" or "stand-by" service. Naturally, the proposal of such a classification of service and the fixing of a charge covering the cost thereof met with strenuous opposition by those (the municipalities) who were suddenly called upon to shoulder the burden of the cost. The opposition cry was "You are trying to rob Peter to save Paul." It was further contended that the ordinary user of water was, as a rule, the tax payer and should stand the burden. Then, too, the making of a tax levy would upset the tax program and interfere in many localities with the tax rate limit. The commission assumed a firm stand and the records show that many decisions rendered provide for a charge against the municipalities for fire service facilities.

Wisconsin Charge for Fire Service Facilities.—By referring to these decisions it will be found that the amount derived from the charge fixed for fire service averages 33 per cent of the gross revenue of the water utility. This would indicate that the Wisconsin Commission places a high value upon such service and were quick to apportion a cost accordingly against those receiving the benefit of the service. Other public utility commissions have, in fixing rates for water works, allowed a charge for fire service facilities. The charge though, in nearly every case, yields a lower percentage of gross revenue than does the Wisconsin Commission's charge.

A California Decision.—In California it is found that the California State Railroad Commission had before it a few years back the problem of fixing a charge against municipalities for fire service. This commission stated:

"In order to furnish adequate protection against fire it is necessary to install facilities of greater capacity than are required to supply ordinary industrial and domestic demands. Such protection is a direct benefit to the community and the excess capacity of the water system which may be deemed justified by the necessity of providing for such emergency demands cannot fairly be charged against regular consumers and paid for under cover of an increase in the unit rates for water consumed for industrial or domestic purposes."

In providing for a charge against municipalities for fire service, in one of its decisions, the California Commission referred to it as "Public Use Charge." The commission apparently resorted to the enforcement of this charge upon municipalities to avoid increasing the rate for domestic and industrial service, as the water utility asked for a higher rate. The charge fixed by the California Commission for fire service in this particular case was evidently intended to be sufficient only to yield the water utility the revenue it was entitled to. The charge fixed for fire service in this case resulted in being a trifle over 7 per cent of the water utility's gross revenue.

The California Commission has on numerous occasions made known to municipalities and apparently in no uncertain terms, its attitude regarding the fixing of a charge against municipalities for fire service.

This commission stated in one of its decisions, ". . . . these municipalities must expect that at the appropriate time, when they are in a position to pay these increased charges, the rates of (name of the utility) will be revised with a view to lifting this burden from general consumers and placing it where it belongs, upon the municipalities."

Application to Municipal Water Works.—So far reference has been made only to what privately owned water works have accomplished in fixing a charge for providing fire service facilities for municipalities (the general public). Why cannot city owned water works fix a charge for similar service and relieve the general consumer of the burden of the cost? Why should the water department in a city furnish free service to the fire department at the expense of the domestic and industrial water consumers?

All cities maintain a fire department equipped with modern fire fighting apparatus and the necessary man power to operate it. Are not the fire service facilities provided by the city owned water works for the exclusive use of the fire department and constructed of sufficient size to render an adequate service in case of fire? Would it not be fair then to relieve the general consumer of the burden of the cost and include it in the fire department budget and tax levy? This method if adopted would result in having those (the general public) who receive the benefit of fire protection pay for it. In reviewing some of the audit reports of city owned water works there appears to be no set-up for such a charge. The city of Los Angeles does in its income statement show the value of some of the water service the city receives free. The value of such free service is shown as part of gross operating revenue and is finally deducted from net income. Merely a bookkeeping transaction.

How East Bay Municipal Utilities District Handles Question.—It is thought that it will be of interest to refer to the charge made by one publicity owned water works in California, the East Bay Municipal Utility District, for providing fire service facilities to municipalities. The Utility District occupies rather a unique position regarding the fixing of rates and charges for the various classes of service it renders. Within its boundary line, on the continental side of San Francisco Bay, are nine municipalities. The district is not city owned. The municipalities are, in fact, the district's customers. Each municipality pays to the district a "readiness to serve" or "stand-by" service charge for providing facilities available for fire service. The amount of revenue derived from the charge for this service is approximately 7 per cent of the total gross revenue of the district The charge is much less than what it should be, considering the value of the service rendered.

What has been stated herein is intended merely as an exposition of what has been accomplished by the management of water works and rate making bodies, in arriving at the cost of and fixing a charge for, fire service furnished to municipalities. It is quite evident that much progress has been made. The trend is and as it rightfully should be, in water works operation, to relieve the ordinary user of water of all costs that are chargeable to other classes of service. Practically 90 per cent of water works consumers are the home and industrial users, and the service rendered to this class is charged for according to the measured volume of water used. Consumers of this class then should not be required to pay any more than the cost of the particular kind of service they receive. The fixing of a charge by water works for "readiness to serve" or "stand-by" service rendered the general public in municipalities for fire purposes will, if made effective, reduce considerably the present cost of service rendered to other classes of consumers.

Acknowledgment.—The above is an abstract of a paper presented at the recent meeting of the California Section of the American Water Works Association.

6th Annual Meeting of the Missouri Water and Sewerage Conference

Problems on the design and operation of municipal water works and sewerage systems were taken up in detail at the Sixth Annual Meeting of the Missouri Water and Sewerage Conference held in Columbia, Mo., Oct. 23-24-25, 1930. Many interesting papers were read and discussed during the meetings. The registration was larger than ever before, 92 persons having registered before the close of the meeting.

The following speakers from out of the state aided in the success of the meeting: J. R. Baylis of Chicago, A. E. Gorman of Newark, N. J., L. H. Enslow of New York, and H. B. Crane of Chicago. The other speakers were well known Missouri men in the water works or sewage treatment field. The conference is particularly indebted to Dean McCaustland of the College of Engineering, University of Missouri, and his faculty who gave valuable assistance on the program.

The conference members were served a luncheon at the Columbia City Water and Light Plant by the city of Columbia, following an inspection of the plant on Thursday, Oct. 23.

The annual banquet was held on the evening of Oct. 24. Dr. James Stewart, State Health Commissioner, was the toastmaster. Doctor Allen, Dean of the Medical School of the University of Missouri, gave a very interesting talk on the evolution of the heart. Other speakers were H. A. Buehler, State Geologist, E. J. McCaustland, Dean of the College of Engineering, University of Missouri, and Hon. W. J. Hetzler, Mayor of Columbia. Music for the dinner was furnished by the School of Fine Arts of the University of Missouri. Following the after dinner talks, much hilarity was occasioned by J. A. Strang's "Rogues' Gallery."

The papers were grouped under three headings as follows: First, papers of general interest, which included such subjects as pumping machinery, distribution system problems, corrosion of mains and other matters which did not pertain directly to the operating problems of those present but contained interesting and useful information to men in the water works and sewage treatment field. Second, papers on water purification problems, which were concerned with preparing water for filtration, filter plant operation problems, and the importance of the chemical and bacteriological laboratories in water purification. Third, papers on sewage treatment, which had to do with sewage pumping stations, foaming of Imhoff tanks, activated sludge process for small cities, and conditions necessary to successful sewage treatment plant operation.

Following the reading of papers Saturday morning, a short business session was held before adjournment. Those present at this meeting were in favor of continuing to hold the annual meeting of the conference in different cities as in the past in preference to locating permanently in one city. Also, the annual water and sewage operators school held under the auspices of the State Board of Health and the Engineering School of the University of Missouri was highly commended and all were in favor of continuing this yearly school.

The following officers were elected for the coming year: Chairman, J. N. Wells, Supt., Joplin Water Works, Joplin; Vice-Chairman, E. E. Wolfe, City Chemist, Hannibal; Secretary-Treasurer, H. D. Peters, Assistant Public Health Engineer, State Board of Health, Jefferson City.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor

Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

Meeting of the North Carolina Sewage Works Association

At the joint meeting of the North Carolina Section of The American Water Works Association and the North Carolina Sewage Works Association at Hendersonville, N. C., on Oct. 13, 14 and 15, two entire sections were devoted to the subjects of sewage and sewage disposal. The attendance was over 180 and included representatives from the New England states to Florida.

The wide interest in sewage works matters in the state of North Carolina as indicated by the attendance from far points was amply justified by the revelation of progress in the art made in that state. A post convention tour of the plants of the state shows that the municipal representatives working in a remarkably intimate cooperation with the engineers of the state department of health are not only applying every scientific development of the art, in both design and operation, but are giving abundance of thought and effort to beauty and appearance. It is indeed a far cry from the weed covered sand or contact beds of a decade ago to the compact, mechanical and almost palatial equipment and housing to be found in these most modern North Carolina plants. The state is exceedingly fortunate that its demands for sewage treatment have developed since the passing of the dark ages and it has no old plants to revamp and no bad precedents to misguide it. Most of all, however, it is fortunate in the cooperative spirit which is everywhere in evidence.

As to the papers read at the meeting, Mr. G. F. Catlette, principal assistant engineer of the state department of health read one on Sewage Flows reporting the painstaking gauging of flows on all the important sewer systems of the state. From these there was produced a curve for "normal hourly variation in flow." Variations from this normal were shown to be surprisingly slight. The form of the curve was almost constant moving slightly forward or back as the outfall was short or long. The most notable variation outside of that caused by industrial waste was in the case of two college towns in both of which the high rate of flow of the afternoon was carried over until midnight instead of falling rapidly after 6 p. m.

The most impressive part of the paper was the production of rate of flow curves for days without rain as compared with the normal curves. Not only did these show that rain is responsible for a large part of the total flow, but more important from design, construction and operating standpoints, is the fact that rain is responsible for the high peaks in the curve to a suprisingly large extent.

In practically every case where a curve was produced for hourly flows for dry periods only, there was no sharp peak but a uniform flow over a period of several hours at a point perhaps 20 per cent below the "normal" peak.

The importance of the suppression of these peaks is well known to every operator whose efficiencies are upset by an hour or so of extra high flow and to every experienced designer who realizes that the nearer the flow can be kept to a straight line the nearer we can get to that ideal plant for which we hope but not too confidently.

The next paper was by John R. Downes, supervising engineer of the Plainfields Joint Sewage Works, on The Separation, Treatment and Disposal of Sewage Solids. This paper emphasized the effect of the efficiency of sedimentation on the digestion of the resulting sludge as well as the effect of grit chambers on the density of the resulting ripe sludge. It also went into the relative importance of sludge drying capacity and sludge digestion capacity and their interrelation.

The paper showed that sludge density, as such, is not as important in ripe sludge as has sometimes been considered.

A series of sludges of varying densities was prepared by diluting a sludge of 7.8 per cent solids with one of 2 per cent solids, both sludges being of the same quality and obtained from different levels of the same digestion tank. When these dilutions were observed side by side in tall glass cylinders, 4 in. in diameter, it was found that the water separated much more quickly from the thinner sludge and that the ultimate separation in inches of water separated from a 9 in. column of sludge, was inversely proportional to the densities.

This liquid was shown to represent that removed from drying sludge by actual drainage while any addition liquid removed must be by the slow process of evaporation.

Experience indicates that a thickness of 4 in. of sludge (after this initial dewatering), will dry very rapidly while depths over 6 in. will dry very slowly.

Applying a chart for the dewatering of sludges of varying densities and a curve for the time required to dry by evaporation different depths of dewatered sludge, a table was produced showing the total time required for drying different density sludges at different depths.

While an 8 per cent sludge contains twice as much solids by weight as a 4 per cent sludge it will take 2½ times as long to dry if both are applied 8 in. deep; 3 times as long if applied 9 in. deep and 4 times as long if applied 10 in. deep.

Good judgment on the part of the operator is required to get the most out of his sludge beds.

Mr. C. C. Hommon, superintendent of the Canton, O., Sewage Works gave a paper on "Utilization of Imhoff Tank Sludge for Farm Fertilizer." Imhoff tank sludge at Canton is pumped to the top of a high point of land on the city farm and from there is run by

means of ditches and furrows to the point of utilization in fertilizing crops.

Three laborers control the distribution of sludge and attend to the farming. The greatest difficulty of controlling the sludge is on very steep slopes that are bare. Vegetation, ice or snow aid greatly in distributing of the sludge evenly. Plowing is very helpful in this distribution not only because the broken land surface helps to divert the flow and spread it but because the plowed land absorbs the moisture rapidly.

Wheat fields flooded after seeding show good growth. Corn so sludged during the past dry season showed wonderful improvement. The sludge is particularly good for grass; but should be used sparringly on oats which tend to grow long, slender, weak stalks which blow down easily. Sludge is not a complete fertilizer for all crops, for instance lime should be added for clover. Indications are that land will require resludging every four years.

A neighboring farmer has installed a pump to reach parts of his farm which cannot be reached directly by the city installation. Adjoining farmers are so well satisfied that they are demanding more sludge. Other farmers further away are pooling their interests to buy pumping equipment.

Bad sludge which is difficult to dry on drying beds is readily disposed of without nuisance by the direct land fertilization method described.

Sludge of high solid content has no advantage in this system and in fact has to be diluted, if too high, to lessen friction.

Costs of this system are certainly no higher and perhaps a little lower than for drying on beds; while the matter of investment is all in favor of direct cropping, and the income from crops readily pays the interest.

Discussion of the above paper brought out the fact

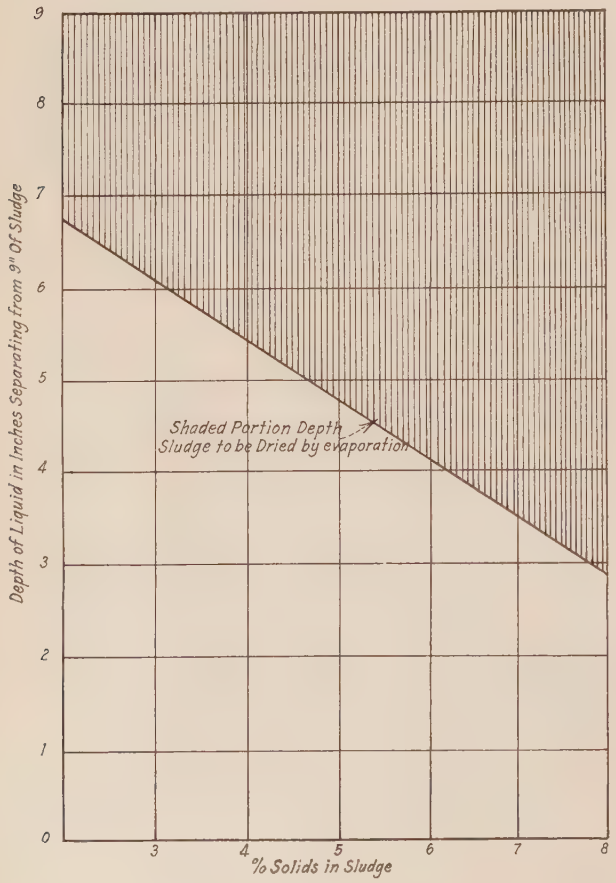

Chart 1

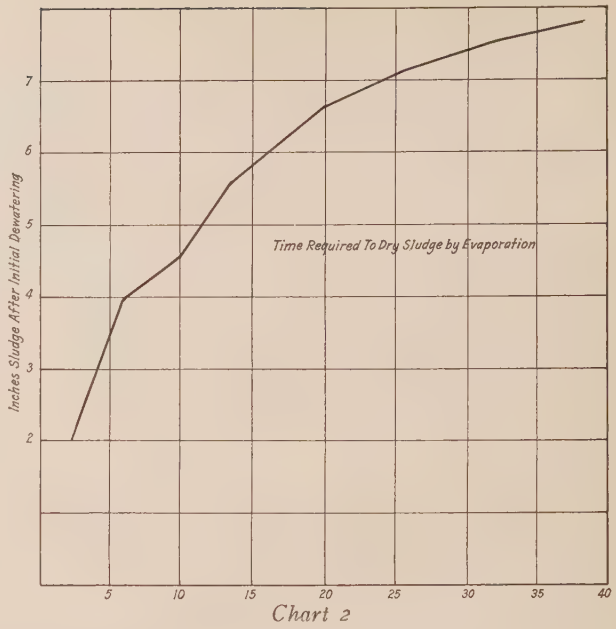

Chart 2

that at Highpoint, N. C., the disposal works are near the city prison farm of 200 acres and the 30 prisoners are used to work the farm using sludge as fertilizer. The plan has not yet been in operation long enough to give reliable results.

At Charlotte where activated sludge is dried directly on Oliver filters and loaded from the belt conveyor into farm wagons it was said that the farmers were not sufficiently attracted by the fertilizer value to keep the sludge away although it was given to them free. Wet weather caused odor troubles with the cake in the case of this activated sludge.

Mr. Roy Lamphere, supervising chemist, sewer department, Worcester, Mass., presented a paper on "Treatment of Sewage Containing Industrial Wastes."

Control of discharge of industrial wastes is very important. Such control can usually be obtained only by cooperation. Precedent in such matters is of the greatest importance. Grasp and hold control from the first. Any relaxation, however small, will result in forfeit of all power.

As illustrating the importance of industry Worcester industries give employment to 35,000 persons with a monthly pay roll of $5,000,000 and have a $190,000,000 investment. Foundry sand is one of the wastes which Mr. Lamphere suggests be intercepted at the source. At Worcester, grease is diverted to the last two tanks by skimmers so that it may be concentrated in one place. It is skimmed off at intervals and burned resulting in local odors for short periods of time.

Lime wastes from tanneries is the source of much odor trouble. Lime wastes plus iron wastes are the sources of the greatest operating difficulties at Worcester.

The quantity of industrial wastes at Worcester may be judged by the fact that normally from 1,500,000 to 2,000,000 gal. of sludge is produced per month. On account of the present business depression this volume had dropped to 1,333,000 gal. in July and to 500,000 gal. in August.

The lime and iron wastes do not interfere seriously with sludge digestion. pH of fresh sludge is 6.6 and that of digested 6.8 to 6.9.

While the settling tank effluent contains from 25 to 50 p.p.m. of iron no abnormal clogging has been noted in the filters. Reduction in the quantities of lime and

iron result in increase in nitrification in the sprinkling filters.

No permanent depreciation of plant traceable to trade wastes has been noted.

Dr. A. J. Fischer, sanitary development engineer, Dorr Co., told of activated sludge digestion at Salem, O.

Plant was designed for 1.5 m.g.d. from 15,000 persons; present flow 1 m.g.d. from 7,000 persons.

Plant consists of bar screen 1¼ in. openings; grit chamber, clarifiers, spiral flow aeration tanks, sludge digester and sludge storage tank. The old filter beds are used for sludge drying and handling storm water flows over 1.5 m.g.d. A chlorine contact basin is at present being used for tertiary sedimentation.

Mr. Fischer's summary states that the experience at Salem shows that activated sludge can be digested in separate digestion tanks. The greatest difficulty encountered was in securing a relatively clear digester overflow. This was overcome by wasting the activated sludge to the primary clarifiers at a very low and constant rate, concentrating the raw-activated sludge mixture and pumping to the digester for short periods at frequent intervals.

The above method of operation gave an overflow containing 0.25 per cent solids (as against 2.0 per cent by other methods), cut down heat losses and produced a thicker digested sludge.

Fifty and six tenths per cent of the total solids or 78.0 per cent of the volatile matter added were digested.

Gas production average 8.22 cu. ft. per pound of volatile matter added and 10.5 cu. ft. per pound of volatile destroyed.

Raw sludge pumped daily averaged 9.47 per cent solids, 35.3 per cent ash; while digested sludge contained 10.47 per cent solids with 58.1 per cent ash.

The Drying of Sludge on Sand Beds

The matter of the relative importance of drainage and of evaporation in the drying of sludge has been one for discussion over a number of years. A combination of experience and experiment indicate to the writer that the relative importance of the two will be governed by the denseness of the sludge and by weather conditions during the first 48 hours of exposure.

The process of drying is divided into two distinct parts: First, the initial dewatering which may remove from practically zero to 66 per cent of the moisture according to the quality of the sludge and its moisture content; second, evaporation.

With a good quality of sludge initial separation of liquid is negligible if the solid content is about 10 per cent and may amount to as much as 66 per cent if the solid content is but 2 per cent.

This initial dewatering may be accomplished in 6 hours in the case of the 2 per cent sludge but will require 48 hours in the case of an 8 per cent sludge.

It is during this initial dewatering period that the effect of rain on the sludge is so devasting; sometimes prolonging the total drying period from a matter of days to one of weeks.

The second part of the drying process, evaporation, depends on climatic conditions but given like conditions a layer of sludge less than 4 in. thick will dry in a few days, whereas if the layer (after the initial dewatering) is over 6 in. thick the drying will be very slow.

Chart 1 (page 396) indicates the proportion of liquid shown by experiment to separate from sludges of different solid contents.

Chart 2 indicates the time observed to be required for the drying by evaporation of different thicknesses of sludge (after the initial dewatering period).

By the use of Chart 1 followed by the use of Chart 2 the following table has been prepared to show the length of time required to dry sludges of different solids contents when applied at depths of 8, 9 and 10 in. to sand beds under favorable conditions.

Per Cent Solids in Sludge	8 In.	9 In.	10 In.
4	5½ days	6 days	6 days
5	6½ days	8½ days	10 days
6	9 days	12 days	13 days
7	12 days	14 days	16 days
8	14 days	18 days	23 days

These depths of sludge have been chosen for example as being within the usual practical range. Much good judgment may be used by the operator in determining the best depth of sludge to be applied taking into consideration weather conditions, etc., as also the convenience of removing the dried sludge frequently in thin dry cakes or at less frequent intervals in a heavier cake.

▼

Financing Sewage Disposal

Connecticut, according to Ohio Health News, seems to have about reached the point where it is ready to follow Ohio's example in establishing the status of sewage treatment and disposal as an essential public utility, to be paid for in the same manner as water supplies are paid for. The success of the system in Ohio, although it by no means has been generally put in force by Ohio municipalities, has thoroughly demonstrated its value at every angle, and to those familiar with its operation, it already is beginning to seem strange that it has not been more generally adopted outside the state. The statute under which this method of financing sewage treatment is developing, known as the "Sewer Rental Law," was enacted by the General Assembly of 1923. Nineteen municipalities are operating under it, and several others are considering its adoption.

According to a recent statement by Sanford H. Wadhams, director of the Connecticut Water Commission, nearly five years of experience with the Connecticut law in trying to solve the state's pollution problem in its rivers and Long Island Sound have resulted only in developing the inevitable conclusion that further progress cannot be expected "until a broader and more intelligent view of the whole problem is adopted."

The chief stumbling block is financial, as it was in Ohio, as Connecticut cities are limited in their capacity to borrow to 5 percent of the grand list. As all public undertakings must be financed out of this money, the competition with other and more popular projects leaves little for development and maintenance of sewer systems and sewage treatment. Mr. Wadhams declares that "unless this question of sewage disposal is regarded as an essential public utility, just as is the supply of a pure and wholesome water, no improvement in the present unfortunate situation can be expected."

He sees no essential difference between piping a water supply into a house and piping that same water supply out of a house after it has been converted into sewage. In conclusion he says:

"A proper conception of the whole subject would be to provide that the householder should pay for sewage removal in the same way as he does for the water supplied him, and on the same basis, that is, by a rate so fixed that it will bear the cost of the service so rendered."

Forms for Filtration Plant Reports

Recommendations of the Committee on Purification Data and Forms of the Water Purification Division of the American Water Works Association

By JOHN R. BAYLIS
Associate Editor

THE chief value of records is having them tabulated in convenient forms and filed so they are readily accessible. Then the performance of a plant may be told very quickly. This means that the essential data should be recorded on as few sheets as is possible. The commitee on Purification Data and Forms of the Water Purification Division of the American Water Works Association is to be commended upon the form they have gotten up for use in monthly reports.

The sheet has a line for each day of the month, and a place for all the data of importance. In fact it is supposed to be a flexible sheet in which such data as the operator considers essential for the operation of the plant may be recorded. If only one chemical is used for coagulating the water, only one heading for chemicals in the report is needed, whereas if three chemicals are used there should be three headings. All of the important tests that are made daily, or several times a month should have a place on the sheet. The sheet may be made most any length desired, for it is folded to letter size for filing.

It is essential that every filtration plant keep certain records, such as the amount of water treated, the amount of chemicals used, certain data on the filters, and certain chemical and bacteriological tests. The chemical and bacteriological tests should be made on the water before treatment, at certain stages of the treatment process, and on the finished product. The advantage of the form adopted by the committee is that the operator can decide on which of the tests are essential for his needs, and the sheet made of sufficient length to include all this data.

The advantage of having all, or as much of the essential data of a plant as possible recorded on one sheet should be apparent. Suppose the B. coli results are high for a day or more. The operator may wish to examine the records for the rate of filtration, the turbidity of the water in the several stages through the plant, the chemicals applied for coagulating the water, the chlorine used, the residual chlorine in the finished water, the B. coli content and bacterial counts through the several stages of the plant, and perhaps other factors, before he can decide definitely the cause for the high B. coli content.

With the data recorded as suggested by the committee, the operator can tell within a very few minutes what was done in the past for each character of water, and the results obtained, so that when there are similar conditions the desired treatment may be determined very quickly. If to do this involved searching through a mass of records which are on separate sheets and filed in different files, it very likely would not be done. The form suggested by the committee should be given very careful consideration by all who are in charge of the operation of filtration plants.

The report of the committee follows:

The Committee on Purification Data and Forms recommends that filter plant operators make their regular monthly reports of plant operation on forms similar to that submitted herewith, and that the following suggestions be given careful consideration:

1. The entire monthly report should be made on a single sheet exactly 11 in. wide and of sufficient length to meet all re-

Remarks:

Day	Million Gallons Treated	Filters: Units Washed	Filters: Average time of Service	Filters: Gallons Filtered per Min. per Sq. Ft. of Area	Filters: Gallons Wash Water	Filters: Per Cent Wash Water	Temp. Fahr.: Air	Temp. Fahr.: Water	Rainfall-Inches	Alum: Pounds	Alum: Pounds per Million Gals.	Alum: Grains per Gallon	Iron: Pounds	Iron: Pounds per Million Gals.	Iron: Grains per Gallon	Lime-CaO: Pounds	Lime-CaO: Pounds per Million Gals.	Lime-CaO: Grains per Gallon	Record in this position copper sulphate, Ammonia, Potassium-permanganate, Soda Ash, etc.	Chlorine: Raw: Pounds	Chlorine: Raw: Pounds per Million Gals.	Chlorine: Raw: Parts per Million	Chlorine: Raw: Residual P.P.M. Applied W.	Chlorine: Raw: Residual P.P.M. Filt. Effluent	Chlorine: Filtered: Pounds	Chlorine: Filtered: Pounds per Million Gals.	Chlorine: Filtered: Part. Per Million	Chlorine: Filtered: Air Temp. Contact Tank Degrees F.	Turbidity: Raw	Turbidity: Applied	Turbidity: Filtered	Color: Raw	Color: Filtered	Hardness: Avail. Bic. Alkalinity: Raw	Hardness: Avail. Bic. Alkalinity: Filtered	Hardness: Soap: Raw	Hardness: Soap: Filtered	pH: Raw	pH: Filtered
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Left Half of Form for Use of Filter Plant Operators in Making Their Regular Monthly Reports of Plant Operations

quirements. The reports can then be folded to 8½ in. x 11 in. size for binding or filing.
2. A 2 in. binding margin should be left on the left hand edge, and at least ¼ in. margin be left on the top, bottom, and right hand edges.
3. The report should be printed or reproduced on thin paper or tracing cloth, so that blue prints can be made.
4. No printing should be put on the back of the sheet.
5. Title should be placed in the upper right hand corner.
6. Remarks should be made in the space to the left of the title.
7. That "milliliter" should be substituted for "cubic centimeter."
8. That in filling in the forms under the head of B. coli, the fractional form be used, the denominator indicating the number of tubes tested, and the numerator indicating the number of tubes positive.
9. That in making annual reports the same general arrangements should be used, but the report should be separated into two sheets, grouping the physical and chemical data on one sheet, and that relating to micro-organisms and bacteria on another sheet. The spacing and lettering should be larger than on the regular monthly report so that photographic reproductions can be made. Monthly averages should be reported. Maximum and minimum results should be for the maximum and minimum day only.
10. If Soda Ash, Ammonia, Copper Sulphate, etc., are used, they should be reported in the position indicated, and where determinations such as Iron, CO_2, Manganese, Oxygen Consumed, etc., are made, they should be added in the position indicated on the blank form.
11. The Commitee realizes the impossibility of recommending a standard form that will meet the needs of every city. Each city finds it desirable to record certain data that would be of no particular value to other cities, but in order to compare the work of one filtration plant with another, it is very desirable insofar as possible, that each city preserves the same order in making reports.
12. The form as recommended by the Committee is particularly useful in permitting a detailed comparison of one filter plant with another. For instance, if it is desired to get an accurate picture of the bacteria growing on agar at 20°C, figures can be taken from the regular monthly reports and curves can be plotted on a single sheet showing graphically the number present in the water for each day in the year. The trend of filter plant performances can then be seen at a glance. If reports are exchanged with other cities and their results are similarly plotted, comparisons may be easily and definitely made. Each step in filter plant operation can be compared in a similar manner. Reports made of monthly averages only, are of very little value for comparing plant performances.
13. The report blank as recommended by the Committee not only represents its opinion, but seems to reflect a growing sentiment among filter plant operators. The Committee went to the trouble of securing blank forms that were used by cities in widely different sections of the country, and while the forms received varied in many particulars, there was a surprising similarity in the general type of many of their report blanks. In recommending this form, the Committee believes that it should prove flexible enough to meet the needs of most filter plants as they are operated today.

The Committee on Purification Data and Forms consists of the following: James W. Armstrong, Chairman, Julius W. Bugbee, Charles R. Cox, Jack J. Hinman, Jr., Harry E. Jordan, Thomas R. Lathrope, Winfield S. Mahlie, Richard Messer, Howard E. Moses, A. U. Sanderson, Wm. M. Wallace.

Sand Washing at Hartford Filters

A new record for speed of sand washing at the West Hartford filters of the water supply of Hartford, Conn., was made last year when two of the ½ acre beds were worked in three days. This was possible because, having the two ¾ acre beds in service, it was safe to have two of the ½ acre beds out of commission at the same time. The following account of the sand washing method is given by Caleb Mills Saville, Manager and Chief Engineer of the Water Department in the annual report for 1929 of the Board of Water Commissioners.

In washing, sand was ejected from the beds to the washers located alongside the sand bin. The clean sand from the water was dropped into another ejector and sent out into the sand bin, the water in which the sand was conveyed then overflowing into a wooden drain at the far side of the bin. Two ejectors were used; each ejector serving two washers arranged in parallel. Three beds were resanded during the year, two in the spring and early summer and one in the fall, and in resanding these, the so-called "Washington" method was used. Boxless ejectors were placed in the sand bin and the sand was conveyed from them to the separators. From the four separators the sand flowed into two ejectors and the mixed sand and water was sent through pipe lines and hose into the bed, discharging free from the hose nozzle.

Title

Record in this position, determinations of Iron, CO_2, Manganese Oxygen consumed, dissolved Oxygen, or any record that may be necessary due to local requirements.

Micro Organisms — Raw: No. per ml.; Standard Units per ml. — Applied: No. per ml.; Standard Units per ml.

Bacteria Per ml. — 20°C on Agar: Raw, Applied, Filtered, Chlorinated — 37°C on Agar: Raw, Applied, Filtered, Final Effluent

B. Coli — Presumtive Test in Lactose Broth — Raw: .001 ml., .01 ml., .1 ml., 1 ml., 10 ml. — Applied: .01 ml., .1 ml., 1 ml., 10 ml. — Filtered: .1 ml., 1 ml., 10 ml. — Final Effluent: 1 ml., 10 ml.

B. Coli — Final Test by Isolation — Raw: .001 ml., .01 ml., .1 ml., 1 ml., 10 ml. — Settled: .01 ml., .1 ml., 1 ml., 10 ml. — Filtered: .1 ml., 1 ml., 10 ml. — Final Effluent: 1 ml., 10 ml.

Day

Mineral Analyses Monthly Composite Parts Per Million — Raw Water — Filtered Water

Day		Raw Water	Filtered Water
1	Silica (SiO_2)		
2			
3	Iron (Fe)		
4			
5	Aluminum (Al)		
6			
7	Calcium (Ca)		
8			
9	Magnesium (Mg)		
10			
11	Sodium & Potassium (Na & K)		
12			
13	Manganese (Mn)		
14			
15	Carbonates (CO_3)		
16			
17	Bicarbonates (HCO_3)		
18			
19	Sulphates (SO_4)		
20			
21	Chloride (Cl)		
22			
23	Nitrates (NO_3)		
24			
25	Alkalinity		
26			
27	Loss on Ignition		
28			
29	Total Dissolved Solids		
30			
31			

Number of Tests

Number Positive

Percent Positive

B. Coli Index by Method

Month

Year 19

Right Half of Form for Use of Filter Plant Opertors in Making Their Reguar Monthly Reports of Plant Operations

Determining the Efficiency of a Distribution System

Simplified Method of Making Direct Fire Flow Tests Through the Use of Existing Fire Hydrants

By MEYER SERKES

Assistant Engineer, Distribution Section, St. Louis Water Department, St. Louis, Mo.

IN the design of the distribution system of a moderate sized town of today, the selections of pipe sizes should be based upon the fire protection requirements.

The rates at which water must be supplied to furnish even moderately adequate fire protection, far exceeds that which is required for ordinary domestic consumption and manufacturing purposes.

Therefore great consideration should be given to the determination of the probable fire demands of a community and the methods as herein mentioned although simple, can very accurately determine the efficiency of your present distribution system to meet such requirements.

There are two principal methods of determining flows in distribution systems.

One, by use of the pitometer or pitot orifice tube, which is inserted into the main through a corporation cock. This method which is quite accurate requires some time for preparation and interpretation.

The other or simpler method is that of direct fire flow tests through the use of existing fire hydrants in your system.

Method of Measuring Hydrant Discharge.—The measurement of the discharge from a fire hydrant, although accurate for all practical purposes, can be made by any water works operator with ease and at very little expense. Sufficient information can thereby be obtained so as to enable one to know exactly what the system will do under almost maximum requirements.

The equipment used consists of a hydrant pitot blade about 4 in. long with a 3 in. pressure gauge attached to same and graduated in ½ lb. divisions, from zero to 50 lb. Several of these outfits should be used, so that two or more hydrant flows can be obtained at one time. Also an additional gauge graduated in 1 lb. divisions from zero to 150 or 200 lb. is necessary to obtain the static and residual pressure during the test.

In making a fire flow test, it is best to use the smaller outlets of the fire hydrant if such are available, as greater accuracy is thereby obtained.

The party making such tests should consist of two or more men, each equipped with a hydrant pitot blade with a gauge attached, and one man to observe the static and residual pressure during the test.

A group of hydrants within a block or two is chosen. At each hydrant an operator is stationed with a pitot blade. At a central hydrant or a house faucet, where no water is being used, a pressure gauge is attached from which the operator observes the static pressure, which is that pressure before the test is started, and the residual pressure or that during the test.

At a prearranged signal with each operator, the hydrants are opened simultaneously and the blades inserted in the stream to obtain the average velocity head emerging in pounds per square inch. The blade should be held about ½ in. from the face of the opening and should be traversed horizontally and vertically to observe the average maximum reading. This, in most cases, is found to be about in the center of the stream, but on large openings of 4 to 4½ in. it is advisable to take a rough average of the pressures across the stream in both directions.

It is best not to open too many outlets so as to lower the pressure in the mains to a figure below that assumed to be the minimum consistent with good fire service, which is 20 lb. where pumpers are used, and 60 to 75 lb. where effective streams direct from hydrants are resorted to. Generally, a test is satisfactory if sufficient water is drawn to lower the pressure in the main 10 or 15 lb. below the normal.

The diameter of each hydrant outlet should be recorded to the nearest 1/16 in.

Formulas for Determining Hydrant Discharge.—With the above observed data it is then very simple to obtain the discharges from the various hydrants from the following formula or tables which were made therefrom.

The formula used in determining the hydrant discharge is as follows:

Discharge in gallons per minute $= 26.9 \times d^2 \sqrt{P}$

Where d = internal diameter of hydrant nozzle in inches

p = the velocity head of the stream expressed in pounds per square inch as indicated by the pilot gauge.

This formula is derived as follows:

Since discharge = (area of outlet) × (average velocity). Using the formula for the area of a circle, and changing (d) to feet, and using the fundamental hydraulic formula Vel. $= \sqrt{2gh}$, changing (p) from pounds per square inch to feet head of water, the above formula becomes

$$\text{Discharge in cubic feet per sec.} = \frac{3.1416 \times d^2}{4 \times 144} \times \sqrt{2g} \times \sqrt{2.31p}$$

$$\text{Discharge in cubic feet per sec.} = .00545 \times d^2 \times 12.2 \times \sqrt{p}$$

$$\text{Discharge in cubic feet per sec.} = .0665 \times d^2 \times \sqrt{p}.$$

$$\text{Discharge in gallons per min.} = .0665 \times d^2 \times \sqrt{p} \times 7.5 \times 60$$

$$\text{Discharge in gallons per min.} = 29.9 \times d^2 \times \sqrt{p}$$

g = acceleration due to gravity = 32.2.

Using a coefficient of 0.90 which has been determined as an average for most hydrant outlets the formula becomes:

$$\text{Discharge in gallons per min.} = 29.9 \times 0.90 \times d^2 \times \sqrt{p} = 26.9 \times d^2 \times \sqrt{p}$$

In making a fire flow test it is sometimes advisable to have another gauge attached to a hydrant outside of the group of hydrants being tested, so as to determine the loss of head in the main arteries.

Knowing the loss of head due to ordinary consumption, and the additional loss due to the measured flow from the hydrants, a very close approximation may be

Table Showing Discharge from Hydrants

DISCHARGE THROUGH CIRCULAR OUTLETS
COEFFICIENT .90 GALLONS PER MINUTE (2½)

PRESSURE	2¼"	2 5/16"	2 3/8"	2 7/16"	2½"	2 9/16"	2 5/8"	2 11/16"	PRESSURE	2¼"	2 5/16"	2 3/8"	2 7/16"	2½"	2 9/16"	2 5/8"	2 11/16"
¼	70	70	80	80	80	90	90	100	10 ¼	440	460	480	510	540	570	590	620
½	90	100	110	110	120	120	130	140	½	440	470	490	520	540	570	600	630
¾	120	120	130	140	140	150	160	170	¾	450	470	500	520	550	580	610	630
1	140	140	150	160	170	180	180	190	11	450	480	500	530	560	590	610	640
¼	150	160	170	180	190	200	210	220	¼	460	480	510	530	560	590	620	650
½	170	180	190	200	210	220	230	240	½	460	490	510	540	570	600	630	660
¾	180	190	200	210	220	230	240	260	¾	470	490	520	550	580	600	630	660
2	190	200	210	230	240	250	260	270	12	470	500	520	550	580	610	640	670
¼	200	220	230	240	250	260	280	290	½	480	510	540	560	590	620	650	690
½	220	230	240	250	270	280	290	310	13	490	520	550	570	610	640	670	700
¾	230	240	250	260	280	290	310	320	½	500	530	560	590	620	650	680	710
3	240	250	260	280	290	310	320	340	14	510	540	570	600	630	660	690	730
¼	250	260	270	290	300	320	330	350	½	520	550	580	610	640	670	700	740
½	250	270	280	300	310	330	350	360	15	530	560	590	620	650	680	720	750
¾	260	280	290	310	330	340	360	370	½	540	570	600	630	660	700	730	760
4	270	290	300	320	340	350	370	390	16	540	570	610	640	670	710	740	780
¼	280	300	310	330	350	360	380	400	½	550	580	620	650	680	720	750	790
½	290	300	320	340	360	370	390	410	17	560	590	620	660	690	730	760	800
¾	300	310	330	350	370	380	400	420	½	570	600	630	670	700	740	770	810
5	300	320	340	360	380	390	410	430	18	580	610	640	680	710	750	780	820
¼	310	330	350	370	390	400	420	440	½	590	620	650	690	720	760	790	830
½	320	340	350	370	390	410	430	450	19	590	630	660	700	730	770	810	840
¾	330	340	360	380	400	420	440	460	½	600	640	670	700	740	780	820	860
6	330	350	370	390	410	430	450	470	20	610	640	680	710	750	790	830	870
¼	340	360	380	400	420	440	460	480	21	620	660	690	730	770	810	850	880
½	350	370	390	410	430	450	470	490	22	640	670	710	750	790	830	870	910
¾	350	370	390	410	440	460	480	500	23	650	690	730	760	810	850	890	930
7	360	380	400	420	440	470	490	510	24	670	700	740	780	830	860	910	950
¼	370	390	410	430	450	480	500	520	25	680	720	760	800	840	880	930	970
½	370	390	410	440	460	480	510	560	26	690	730	770	810	860	900	940	990
¾	380	400	420	440	470	490	510	540	27	710	750	790	830	870	920	960	1010
8	380	410	430	450	480	500	520	550	28	720	760	800	840	890	930	970	1020
¼	390	420	430	460	480	510	530	560	29	730	770	820	860	910	950	990	1040
½	400	420	440	460	490	510	540	560	30	750	790	830	870	920	970	1010	1060
¾	400	420	450	470	500	520	550	570	31	760	800	840	890	940	980	1030	1080
9	410	430	450	480	500	530	550	580	32	770	810	860	900	950	1000	1040	1100
¼	410	440	460	480	510	540	560	580	33	780	830	870	920	970	1010	1060	1110
½	420	440	470	490	520	540	570	600	34	790	840	880	930	980	1030	1070	1130
¾	420	450	470	500	530	550	580	600	35	810	850	900	940	990	1040	1090	1140
10	430	450	480	500	530	560	580	610	36	820	860	910	960	1010	1060	1110	1160

made of the quantity available at any given pressure.

Great care should be taken in the selection of the hydrant, where the residual gauge is to be located as the accuracy of the test is hereby effected. It should be placed as close as possible to the center of the groups of hydrants from which the flows are to be measured.

With a known drop of pressure in the mains and with a known quantity of water drawn, it is comparatively easy by using a hydraulic slide rule to obtain the quantity of water available at any residual pressure.

This method can be used in connection with most tests, but cannot be used where the assumed residual pressure would lower the hydraulic grade line below the high point of any main between the pumps or supply works and the test.

In making flow tests and in studying the results, actual conditions at times of serious fires should be taken into consideration.

For example, tests made upon a system where a small standpipe is near the point of test would give an erroneous result, as the greater part of the flow for the first few minutes would come from the standpipe. In such cases it is best to make the test with the standpipe cut off.

Such fire flow tests when properly made and interpreted are indicative of numerous defects that may exist in a system, such as closed valves, acute bends, sediment in the main, or that the main in question is not properly interconnected with proximate feeders.

In all metropolitan cities of today such tests are continuously made to obtain data which is used as a basis in determining the reinforcements necessary in those sections where the fire supply has shown deficient.

All fire protection engineers of today, in making reports upon the adequacy and reliability of water systems, find that fire flow tests are undoubtedly the most practical, economical and most instructive method of studying the efficiency of a distribution system.

Such tests as these should be most profitable to water works engineers in designing and planning reinforcements to their distribution system, and in keeping well informed of the condition as it exists.

Determining Pressure Losses by Hydrant Flow Measurements.—Hydrant discharge measurements can likewise be made with sufficient accuracy in order to determine the friction coefficient or "C" in William and Hazens formula for mains ranging in size from 3 in. to 12 in. For the larger mains a great number of hydrants would be required to be opened in order to obtain a velocity greater than 1 foot per second, so as to insure any degree of accuracy.

In making such tests the main in question must be isolated, so that the same amount of water passes the two points at which the instruments are attached. In other words the supply must come from one end only and leave through the discharge openings which are being measured. All large service connections or branch connections must be shut so as to have a uniform velocity across the entire stretch.

There are two methods of obtaining the pressure losses required for the determination of "C."

Table Showing Discharge from Hydrants

DISCHARGE THROUGH CIRCULAR OUTLETS
COEFFICIENT .90 GALLONS PER MINUTE (4½)

PRESSURE	4¼"	4 5/16"	4 3/8"	4 7/16"	4½"	4 9/16"	4 5/8"	4 11/16"	PRESSURE	4¼"	4 5/16"	4 3/8"	4 7/16"	4½"	4 9/16"	4 5/8"	4 11/16"
¼	240	250	260	270	270	280	290	300	10 ¼	1560	1600	1650	1700	1740	1790	1840	1890
½	340	350	370	380	390	400	410	420	½	1580	1620	1670	1720	1760	1810	1860	1910
¾	420	430	450	460	470	490	500	510	¾	1590	1640	1690	1740	1790	1880	1880	1940
1	490	500	520	530	550	560	570	590	11	1610	1660	1710	1760	1810	1860	1910	1960
¼	540	560	590	590	610	630	640	660	¼	1630	1680	1730	1780	1830	1880	1930	1980
½	600	610	630	650	670	690	700	720	½	1650	1700	1750	1800	1850	1900	1950	2000
¾	640	660	690	700	720	740	760	780	¾	1670	1720	1760	1820	1870	1920	1970	2020
2	690	710	730	750	770	790	810	840	12	1690	1730	1780	1840	1890	1940	1990	2050
¼	730	750	780	800	820	840	860	890	½	1720	1770	1820	1870	1930	1980	2030	2090
½	770	790	820	840	860	890	910	940	13	1750	1800	1860	1910	1970	2020	2070	2130
¾	810	830	860	880	900	930	950	980	½	1790	1840	1880	1950	2000	2060	2110	2170
3	840	870	900	920	940	970	1000	1020	14	1820	1870	1930	1980	2040	2090	2150	2210
¼	880	900	930	960	980	1010	1040	1060	½	1850	1910	1960	2020	2080	2130	2190	2250
½	910	940	970	990	1020	1050	1070	1100	15	1880	1940	1990	2050	2110	2170	2230	2290
¾	940	970	1000	1030	1050	1080	1110	1140	½	1920	1970	2030	2090	2150	2200	2260	2330
4	970	1000	1030	1060	1090	1120	1150	1180	16	1950	2000	2060	2120	2180	2240	2300	2360
¼	1000	1030	1060	1090	1120	1150	1180	1220	½	1980	2030	2090	2150	2210	2270	2330	2400
½	1030	1060	1090	1120	1160	1190	1220	1250	17	2010	2060	2120	2180	2250	2310	2370	2440
¾	1060	1090	1120	1150	1190	1220	1250	1290	½	2040	2090	2160	2220	2280	2340	2400	2470
5	1090	1120	1150	1190	1220	1250	1280	1320	18	2060	2130	2180	2250	2310	2370	2440	2510
¼	1110	1150	1180	1210	1250	1280	1320	1350	½	2090	2150	2220	2280	2350	2410	2470	2540
½	1140	1180	1210	1240	1280	1310	1350	1390	19	2120	2180	2250	2310	2380	2440	2510	2580
¾	1170	1200	1240	1270	1310	1340	1380	1420	½	2150	2210	2280	2340	2410	2470	2540	2610
6	1190	1230	1260	1300	1330	1370	1410	1450	20	2180	2240	2300	2370	2440	2500	2570	2640
¼	1220	1250	1290	1320	1360	1400	1440	1480	21	2230	2290	2360	2430	2500	2560	2630	2710
½	1240	1280	1310	1350	1390	1430	1470	1510	22	2290	2350	2420	2490	2560	2620	2700	2770
¾	1260	1300	1340	1380	1420	1450	1490	1540	23	2340	2400	2470	2540	2610	2690	2760	2820
7	1290	1330	1360	1400	1440	1480	1520	1560	24	2380	2460	2520	2600	2670	2740	2820	2900
¼	1310	1350	1390	1430	1470	1510	1550	1590	25	2430	2510	2580	2650	2720	2800	2870	2960
½	1330	1370	1410	1450	1490	1530	1570	1620	26	2480	2550	2630	2700	2780	2850	2930	3020
¾	1350	1390	1430	1480	1520	1560	1600	1640	27	2530	2600	2680	2760	2830	2910	2990	3070
8	1380	1420	1460	1500	1540	1580	1620	1670	28	2580	2650	2730	2800	2880	2960	3040	3130
¼	1400	1440	1480	1520	1570	1610	1650	1700	29	2620	2700	2770	2850	2940	3020	3090	3180
½	1420	1460	1500	1540	1590	1630	1680	1720	30	2670	2740	2820	2900	2990	3070	3150	3240
¾	1440	1480	1520	1570	1610	1650	1700	1750	31	2710	2790	2870	2950	3030	3120	3200	3290
9	1460	1500	1540	1590	1630	1680	1720	1770	32	2750	2830	2920	3000	3080	3170	3250	3340
¼	1480	1520	1570	1610	1660	1700	1750	1800	33	2800	2880	2960	3040	3130	3220	3300	3390
½	1500	1540	1590	1630	1680	1720	1770	1820	34	2840	2920	3000	3090	3190	3260	3350	3440
¾	1520	1560	1610	1650	1700	1750	1790	1840	35	2880	2960	3050	3140	3210	3310	3400	3500
10	1540	1580	1630	1670	1720	1770	1820	1870	36	2920	3000	3090	3180	3270	3360	3450	3540

One by the use of ordinary pressure gauges, the other by use of the sensitive differential gauge.

In using ordinary pressure gauges, greater stretches of pipe can be taken, whereas with the differential gauge only lengths from 300 to 700 feet, in most cases, are economically available for test.

In using pressure gauges, two hydrants, some known distance apart are chosen, at which the gauges are attached and the correct elevation of these gauges determined. If possible sensitive gauges reading as close as one foot head should be used, if available.

Computing Loss of Head.—One or more hydrants are opened from which the amounts of water flowing is obtained by use of the pilot blade, and the pressures observed simultaneous at the gauges. Having obtained this data, the loss of head and the friction coefficient can be readily computed by the ordinary formulas:

Quantity of discharge = Velocity × Area of pipe or

$$\text{Vel.} = \frac{\text{Quantity}}{\text{Area}};$$

Substituting Velocity in Chezy's formula, Vel. in ft. per sec. $= C\sqrt{RS}$:

where R = Hydraulic radius $= \frac{\text{Diameter of pipe in ft.}}{4}$

S = Slope per foot of pipe

and solving for "C" the friction coefficient.

In the use of the simple differential pressure gauge, a short stretch of main between two fire hydrants, house service taps or faucets can be used.

Within the differential gauge, which is merely a "U" tube 10 or 20 in. high, a liquid heavier than water is placed, such as carbon-tetrachloride, Bromoform, or mercury, as may be needed.

The "U" tube is connected up by means of ordinary garden hose to each fire hydrant or house faucet, making sure that no leak occurs on any part of the hose connection, house faucet, or service pipe.

In this test one fire hydrant is usually sufficient to be opened and the discharge observed by the pilot blade or by means of a 3 or 4 in. accurate meter attached to the hydrant.

While the discharge is being measured by one observer, the deflection in inches or the direct pressure loss at the differential gauge is observed by another. Should the deflection be too great to be observed within the range of the "U" tube by the use of carbon-tetrachloride, the solution should be changed to Bromoform, or mercury.

Thirty second readings for 5 or 10 minutes should be taken in both tests, either at the gauges or at the deflection tube so that fair averages are obtained.

Knowing the distance between the hydrants or points at which the hoses were attached, it then becomes a problem of again solving for "C" in the Chezy's formula. $V = C\sqrt{RS}$.

The head loss between the two points in the main as observed by the deflection on the differential gauge is as follows:

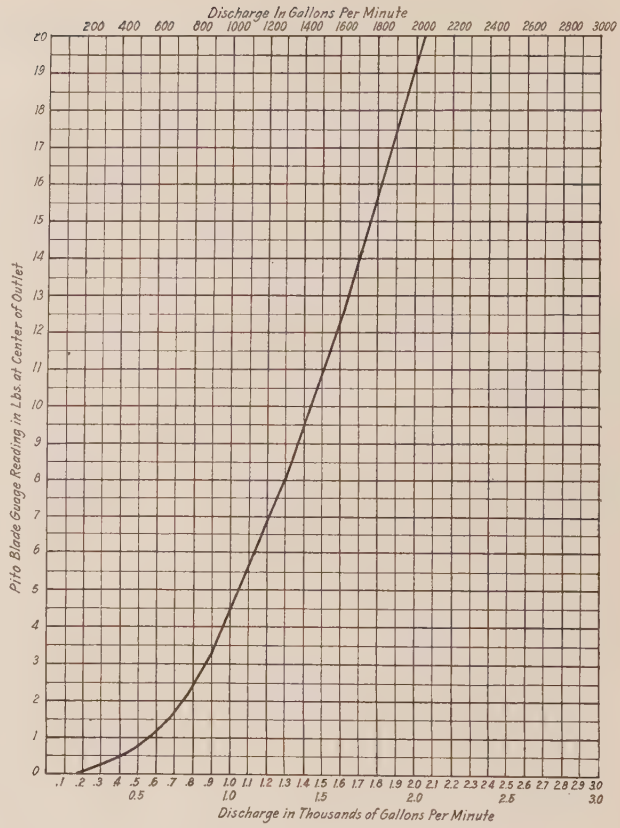
$$\text{Head loss in feet} = d\frac{s^1 - s}{s}$$

in which d = deflection in feet

s^1 = specific gravity of heavy liquid

s = specific gravity of water

Gravity of carbon-tetrachloride	1.60
Bromoform	2.75
Mercury	13.58



Curve Showing Actual Flow for 4½ In Fire Hydrant Outlet

If a hydraulic slide rule is available the "C" can very readily be obtained by knowing velocity in feet per second, slope in feet per 1,000 ft. and diameter of the pipe.

The "C" or friction coefficient thus obtained can then be compared with the "C" for various ages of pipe as in William & Hazen Hydraulic Tables, whereby a fair idea of the interior condition of the pipe is determined. "C" for new pipe ranging from 120 to 130.

Such tests as those along sections of mains are valuable in locating obstructions or partly closed valves, by noting unequal drops of pressure or losses in different sections of the pipe length. It can also be used in determining the necessity of cleaning a main or its effectiveness after cleaning has been accomplished.

Acknowledgment.—The foregoing is a paper presented Oct. 24 at the 6th annual Missouri Water and Sewerage Conference.

WATER MAINS LAID ON TOP OF GROUND.—The installation of water works for the city of Churchill, the northern terminus of the Hudson Bay Ry. in Ontario, involved an interesting problem as ordinary methods of laying the mains below the frost line were not suitable.

Borings as deep as 117 ft. have reached solid rock before coming to the end of the frozen soil which never thaws out. It is stated the mains will be laid on top of the ground and covered all around with 4 ft. of dry moss. The pipes will be supported on wooden posts driven into the clay, and when covered with the moss, will be sheeted with sheet iron and thatched straw to prevent the moss from getting wet, thus turning it into a good conductor of cold.

Automatic Water Pumping Stations at Baltimore

Elements of Design Entering into Automatic Electric Stations and Operating Experiences with Certain Features of Such Stations

By LEON SMALL

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THIS subject should be one of lively interest to those engaged in water works practice, as the economies to be gained by an automatic system of operation which permits the absence of an operating personnel, are quite marked. There may be an impression that the absence of attendants in such a station mitigates against the reliability of the plant operation, but the writer submits that this consideration, while of prime importance generally in water works service, is not a serious factor, and with the increased reliability that has developed in the past few years in power supply control apparatus, and the other elements upon which the continuous service of a pumping station is dependent, the automatic station stands alone in its field. In line with this thought, it may be generally considered as axiomatic that with any electrically operated machinery, whatever can be done by manual control can be done better by automatic electrical control, and an experience of a number of years in the design, construction and operation of electrically powered pumping stations has convinced the writer of the truth of this assertion.

The present discussion will be limited to electrically operated automatic stations, without prime mover emergency stand-by units, discharging into a standpipe or similar means of reserve, as it is considered that the application of such stations is limited to this class of service. In this connection, it should be noted that, while this discussion is confined to an electrical drive, the automatic operation is not necessarily limited to this, but it may be applied, with proper adaptation, to gasoline or oil engine drives, combinations of these with motor drives, or other suitable sources and combinations of energy that may be selected, and with the pumps discharging into open or closed systems.

The Pumping Station.—The housing of the equipment for an automatic station is a most important consideration and the two elements that should be carefully considered in this connection are those for the protection against freezing and provision for proper drainage. Any freezing protection dependent upon artificial heat, such as electric heating units, is not thoroughly dependable, and in two instances in Baltimore where electrical heating was provided for freezing protection in an automatic station, the heating system has failed, resulting in the breakdown of the control system and expensive repairs to Venturi meters, gauges, and other water-actuated apparatus. The station in which this damage was done was not designed or built by the city, but was acquired and operated by the municipality in connection with the expansion of the water supply system that has followed the Annexation Act of 1918; we mention this to explain the apparent inconsistency between our theory and our practice in this connection.

The most effective, economical and certain way of protecting against freezing is to place the main portion of the structure below ground, with sufficient earth covering above to insure that freezing temperatures will never obtain in the pump room. All of the stations that we have designed and built have been constructed along these lines, and it has been found that with an 18 in. covering of earth over the top slab of the buried portion of the structure, the lowest temperature reached in a pump room has been 35° F., this being at a time when the outside temperature during the night fell to 5° below zero and the operation of the pumping machinery, with its consequent generation of heat, had been suspended for a period of more than four hours. To gain access to the pump rooms, these stations are built with a structure outside the wall of the main portion to form a stairwell, and in this construction is included an arrangement of two doors, one at a middle landing on the steps and one at the bottom of the steps where it enters the pump room, these forming an air lock to arrest the transfer of heat by way of the stairwell construction. The opening of the stairwell at the ground level is surmounted by a brick structure about eight feet square in plan, and within this there is placed the electrical service entrance and metering equipment. The outside door is arranged with a double hasp locking device, with separate locks for water bureau and power company employees, and by this means the power company can gain access at all times for reading the meters; the next door on the middle landing below can be opened only by Water Bureau employees. The structures are arranged in each case so that the entrance door faces toward the south and opens in, this detail being one intended to give the minimum interference with access to the building which may result from heavy snowfalls or freezing weather. The size and arrangement of the stairwells is such that the large machinery cannot be readily passed to the pump room, and to provide for the handling of such equipment, the top slab is pierced with a suitable sized opening having walls extended above the ground level, this opening, when not in use, being closed with a heavy concrete slab built with overhanging edges. To give proper ventilation in warm weather, the top edge of the opening in which the cover slab rests are provided with a series of 3 in. depressions, and these, together with the projection of the cover slab, permit the escape of heated air, at the same time forming effective protection against the elements. In addition to this ventilating arrangement, we have provided in each structure a short section of 16 in. pipe leading through the top slab to above the ground surface, this being intended to receive a ventilating fan, if such an arrangement would be found necessary in extremely warm weather, but so far with the stations we have built, the ventilating fan has been found unnecessary.

Location of Station.—The location of the structure under ground may introduce difficulties in some localities on account of drainage, but in Baltimore we have been fortunate in our permissible choice of topography

and in every case have been able to obtain a gravity drainage line. Where conditions would not permit gravity drainage and sump pumpage would have to be resorted to, a dual arrangement of both electrically operated and water ejector means of sump unwatering should be adopted, as an accumulation of water which might follow the failure of an unwatering system, would be highly undesirable, to say the least. In addition to the necessity for getting rid of waste water which accumulates in the station sump incident to operation, it is also necessary to keep surface drainage from penetrating the structure and creating a damp condition. To satisfy this requirement, the entire structure from the ground line to the bottom of the wall footings should be protected by a membrane waterproofing, with an outside tile drain line carried around the footings and led into the sump. The last station we have built includes this method of waterproofing, and the results have been very satisfactory, notwithstanding the location of the station at an elevation considerably below the bottom of an adjacent reservoir.

The Electric Service.—The equipment for the station should be divided into two or more units, and if two units are used, these should be in duplicate and interchangeable to permit a transfer of a portion of one unit to the other in case this is necessary. The electric service to the station should be brought in underground from the pole line, and this arrangement, while somewhat more costly initially, contributes considerably to the neatness of appearance of the surroundings and allows complete freedom of choice as to the direction in which the service is brought. In addition, the underground arrangement gives the very practical benefit of minimizing the effects of lightning discharges on the power lines, and even with a direct stroke immediately at the point where the service is taken from the pole line, the effects of the lightning discharge, if it followed the station service, would be dissipated in the ground before it would expend its force on the station equipment. The most serious trouble with station apparatus which we have had from lightning, with the underground power lead-in, has been the effects of line voltage surges which accompany the stroke, and in one instance, this caused the breakdown of the insulation on a no-voltage holding coil. A properly functioning lightning arrester will not afford better protection against the effects of lightning and the underground lead-in gives practically the same results as an arrester, with the additional advantages that have been indicated, as well as being free of the necessity for maintenance attention which the arrester requires.

From the service entrance the circuit should be led through a fused disconnecting switch to the control panel, with the fuses of such capacity as to be the strongest link in the chain of over-current protection devices, but not so strong as to fail only after permanent damage has been suffered by the apparatus in the event of an over-current condition. For stations of the size we are considering, 440 volts is our standard potential and this permits the circuit to be handled through an air type breaker mounted on the station control panel. This breaker should be provided with magnetic overload protection, with means for ready calibration, but a no-voltage release device should not be included on the breaker unless the latter is of the automatic reclosing type, as a momentary voltage dip may cause the no-voltage release device to open the breaker and the station would be inoperative until attention was received. After leaving the main breaker, the circuit should be carried through the desired metering instrument elements and led to a bus construction from which the two or more motors in the station are fed. Each circuit feeding the motor should take off through a disconnecting switch so that the opening of this will kill the corresponding motor and starter and thus permit repairs to be carried on without interfering with the operation of the remainder of the station equipment.

Motor Starters.—The type of motor starters that may be used depends upon the kind of motor that is selected and the starting current limitations of the power company. A variety of starters for performing the required service are available, and the proper choice depends upon the local conditions to be met. Whatever starter is selected, it should be provided with thermal overload protection in two phases, and so constructed as to be able to withstand successfully a number of starts in close succession. Such starters with automatic operation being dependent upon magnetically-operated contacts, inherently include no-voltage protection and for this reason, the omission of a no-voltage release on the main panel breaker, referred to above, is of minor importance. However, if the power supply is subject to interruptions, particularly partial ones resulting in single phase service, these may be provided against by the proper arrangement of potential and current phase balance relays, timing relays, and re-closing breakers; with such apparatus, the equipment will open the circuits upon the development of partial or complete faults, wait a definite interval to allow apparatus to cool or a fault to be corrected, reclose circuits at the expiration of an interval or when phase potentials are in balance and in any similar predetermined manner follow orders explicitly, without the necessity of having them repeated or typed and posted on a bulletin board, and with never a thought of a vacation, days off to attend to private business, or a demand for overtime for performing this service twenty-four hours daily.

Either the squirrel cage or the wound rotor induction motors are available for service such as we are considering; synchronous motors, of course, may also be chosen, but unless there are strong inducements offered for their use by the power company wishing to gain the benefits of the power factor correction feature of the synchronous motor, the comparative complications of this type do not commend them for the presently-considered form of application. The squirrel cage induction motor presents advantages over the other types, among which may be noted lower first cost, simplicity and ruggedness, high efficiency, and the ability to operate at higher speeds safely. Their application generally, however, is handicapped by the high starting current inrush that is a squirrel cage characteristic, although recent designs of deep bar and double cage windings on squirrel cage rotors have improved these motors to an extent that has considerably enlarged the field of squirrel cage application which has been limited in the past by the starting characteristics. It should be noted that the limitations on the use of squirrel cage motors relate to and are governed by the power company's restrictions on permissible starting currents, and aside from these considerations, the squirrel cage characteristics do not handicap the design of the station equipment. With a properly designed squirrel cage motor and starter, and special provisions made to limit the load on the motor until the machine is up to speed, however, a starting inrush of 200 per cent of normal current can easily be met, and there are applications in Baltimore in which large squirrel cage motors up to 500 and 1,000 hp. are being started with a 150 per cent current limit.

The wound rotor induction motor offers a ready solution in the event that the squirrel cage application cannot be worked out, and the installation of this type will usually simplify the starting equipment to an extent that apparently indicates the wound rotor motor is a preferable one from an over-all viewpoint. It should be borne in mind, however, that upon the motor depends to a large extent the successful operation of the station, and the primarily apparent advantages which may appear from the installation of a wound rotor drive, should not be allowed to overbalance the lasting benefits of maximum dependability that is an outstanding quality of the squirrel cage construction.

The Equipment Control System.—One of the most important features of an automatic station is the control system by which the operation of the equipment is governed. The systems by which the head of water in the reservoir or standpipe governs the pumping equipment fall into three general classes: 1—float switch in the tank, with control wires led back to the station; 2—separate pressure line from the tank to the station; 3—altitude valve at tank, arranged to close when the tank is full and in this manner build up pressure on the entire distribution system above the normal operating point, thus effecting the function desired.

Of these three general schemes, the float switch is the least desirable in water works practice, due to the complications that are brought about by freezing and the necessity for maintaining the control wires from the tank to the station. It is the simplest method, however, and where the distances are short and climatic conditions are favorable or proper means can be provided for overcoming the effects of ice on the float, this method is acceptable and, no doubt, is used in a large number of cases.

The separate pressure line between the tank and the station, although overcoming the objection on the grounds of freezing that handicaps the float switch method, entails considerable installation expense, and the pressure line is a weakness that must be constantly protected to insure the continuity of station operation. In addition to these disadvantages, the direct pressure system may, in some installations, give an operating range for control that is a very small percentage of the total head pumped against, and as pressure actuated contact making devices are none too sensitive at best, any system in which the total range of pressures between the start and stop positions is a small proportion of the total pressure that must be borne by the contact gauge, should be avoided. This system also presents the disadvantage of making and breaking contacts very slowly, with the detrimental results that always follow such procedure. We have one installation in Baltimore that has been temporarily working on this direct pressure system and the initiation of its use developed an unusual and totally unexpected condition. The contact gauge controlled by the pressure pipe was mounted on a small sub-panel along with a relay controlled by the gauge, the relay being so constructed that upon closure it would latch in mechanically and remain latched until the standpipe was filled. As the standpipe emptied, the gauge contact would slowly approach the starting position and finally make contact very lightly, so that the relay would draw its armature into the closed position to latch. The movement of the relay jarred the panel upon which it was mounted sufficiently to momentarily open the gauge contacts before the relay latch caught, with the result that the relay armature would fall out again, this cycle continuing with destructive effects on the entire control system until the standpipe pressure fell low enough to effect a positive gauge contact closure; the trouble was overcome only by physically separating the contact gauge and relay; this incident is brought out to illustrate one of the disadvantages that may follow the use of the direct pressure control systems, with the slow closure of contacts that is a concomitant of this system.

The third method outlined offers the cheapest and most satisfactory and reliable method of control operation that has been developed. To repeat, this system consists of an altitude valve placed in the discharge line where it enters the standpipe or reservoir, arranged to shut when the tank reaches the desired level and open again after the level has fallen four or more feet. A by-pass, with check valve, is inserted around the altitude valve to permit the tank to discharge into the system after the pumps are shut down and before the altitude valve re-opens. This method of control offers the advantage of having all the elements gathered at one point in an underground frostproof vault, and under normal conditions nothing short of a break in the distribution system can disarrange its operation. Its use also simplifies the adjustment of the control devices in the station, as the system pressure, when the standpipe is full and the altitude valve closes, builds up abruptly and definitely, giving a positive cut-off point that is not dependent upon close or maintained adjustment.

All of the stations in Baltimore, except the one mentioned with the temporary direct pressure system, are operating, or are being designed and constructed to operate, on the altitude valve control method, these installations ranging in size up to stations having individual units with capacities of 10,000 g.p.m. One station now under construction will be controlled by an altitude valve installation at a reservoir, with the altitude valve governed by a hydrostatic head-mercury balance device that is sufficiently sensitive to cause the altitude valve to open and shut from a range in reservoir levels of not more than six inches. In this particular installation, closure of the altitude valve will shut down the station, the pump will start again at the expiration of a pre-determined time interval which is initiated coincidentally with the preceding shut-down operation. Controlling the start in this manner avoids the uncertainty which would otherwise result from an attempt to control by pressure drop, where the greatest permissible reservoir water level range represents a head that is but a small proportion of the total head on the pumping system.

Pressure Wave Dampening Tank.—A point that is often overlooked in the design of station control apparatus is the necessity of a pressure wave damping tank in the lines leading to the contact gauges. Without such devices the contact gauges will follow the amplitude of the pressure surges that occur subsequent to the shutting down of a pump, and not infrequently the discharge main pressure will dip sufficiently low, immediately following a pump shut-down, to cause the equipment to start again. This, of course, results in the immediate building up of a pressure head to the shut-off point, and the unit again shuts down, only to be followed by another cycle of starting and stopping. In one instance the writer knows of an installation without a damping tank in which a unit started and stopped in this manner two times a minute for thirteen hours, with results to the starting equipment that can well be imagined, not to mention six failures in the distribution system during this period. In a Bourdon tube type of pressure gauge, but a few drops of water are required to be introduced into the tube to cause the gauge to go through its entire range, and from this can

be realized the futility of attempting to damp the contact gauge action by a throttling device only. An air chamber of about five gallons capacity introduced in the gauge line, behind a needle valve or fixed orifice inserted in the pressure line between the discharge main and the tank, will give all the damping effect that is necessary, and such a device will permit pressures to be transmited very slowly to the contact gauge, at the same time giving a positive control of fluctuations.

The Pumps.—The choice of pumps for an automatic station depends upon the conditions to be met and a discussion of the kinds that are available is not a part of this article. The centrifugal pump, of course, is almost universally used, but the displacement type of any kind is as adaptable to automatic operation as is the centrifugal. In a centrifugal pump installation, however, it should be borne in mind, where the system is to be controlled by the altitude valve method, that the discharge head conditions of the distribution system must be carefully considered, and the head-discharge charactertistics of the pump should be such that sufficient head is developed to give an ample operating range when the altitude valve closes. Similarly, for a displacement pump installation to be controlled by an altitude valve, the possible effects of high pressures building up after altitude valve closure should not be overlooked, and proper provisions made to guard against the creation of what may readily become destructive pressure valves.

With an underground station such as we have indicated as being desirable, there is usually no difficulty about priming the pumps if centrifugals are selected, but if priming is a condition that must be met, automatic priming has been successfully developed and used over a sufficient period of time to demonstrate its entire dependability. If priming must be a part of the station operation, this feature requires merely another element that must be provided in the starting equipment before the main pumps are placed in service.

Valves.—Station valves would seem to be a form of equipment so old and well developed as to be beyond the scope of discussion, but it is surprising what an amount of trouble can be gotten into unless proper attention is paid to these details. Check valves in the discharge lines are particular offenders and if they are the usual swinging disc type and put in the line without any thought of subsequent maintenance, the disc may soon wear and drop from its hinge pin, particularly if the demands on the distribution system are subject to severe fluctuations. In Baltimore, more than one disc has disappeared from a check valve without leaving any notice of its departure and in some instances, they have worn so as to cock into a partly open position on closure, and then slam shut when the full reverse flow developed; in one instance this caused a water hammer that resulted in a complete rupture of the check valve body. Where fluctuations may be expected or developed, the swinging disc type of check valve may be given long life and be comparatively trouble free if it is blocked so that it cannot swing freely and entirely open, but is always held steady in the allowed open position, with a positive pressure against the stop. There may be a technical objection to this on the grounds of increased friction losses, but we believe any determination of losses resulting from this procedure would be practically limited to a theoretical discussion, and the reliability of the check valve, together with the absence of necessity for maintenance, which follows the use of the blocking method, more than makes up for any actual losses that result.

The pump discharge valves in the usual layout of automatic stations are generally open, with the water held by a check valve. Such an arrangement permits the pump to impose a load on its motor as soon as the speed reaches the point where the head developed is sufficient to lift the check valve against the distribution system pressure; often this condition is highly undesirable, as it means that the motor is being placed under load before it is in the full running position. Such a station design and operation presents an unnecessary handicap upon the use of a squirrel cage motor, with its less favorable starting qualities, and the cause for such conditions may be readily avoided by the proper attention to design. In Baltimore, the solution of this problem is found by having the discharge valves hydraulically operated and automatically controlled, and shut when the pump unit is down. The admission of water to the hydraulic operating cylinder is controlled by a pilot valve, this being governed in turn by a mechanism which is normally held in the "off" position by spring pressure, with the force of the spring being overcome by water pressure in an auxiliary hydraulic cylinder, the latter being connected by a pressure line to the pump discharge nozzle. By this means, a pump is started and brought up to speed before the discharge valve is open, in this manner limiting the load on the motor to between 35 and 40 per cent of full load until the running contacts of the motor starter are closed. Succeeding the shut-down of the pump, the hydraulic valve control device returns the discharge valve to the closed position, this system affording double protection in the event of a check valve failure, as well as, through limiting the starting load permitting the application of the more desirable squirrel cage motor under conditions where otherwise the squirrel cage type may not have been acceptable to the power company.

Acknowledgment—The above is an abstract of a paper presented at the 4th annual conference of the Maryland Water and Sewerage Association.

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Eliminating Unnecessary Use of Fire Hydrants

In the superintendent's round table (see October Journal American Water Works Association) at the 1930 convention of the association, C. W. Winkle, superintendent, maintenance and transportation, Indianapolis, Ind., Water Co., stated that in an effort to eliminate all unnecessary use of public fire hydrants in Indianapolis, the Indianapolis Water Co. set aside 20 smaller type fire hydrants in the high value district, and these were equipped with special 1⅞-in. inside diameter connections for use by the street flushing crews, or other city employes charged with the use of city water. In addition, 1⅞-in. inside diameter connections were placed on one nozzle of approximately 175 fire hydrants in the city, and the street sweeping and flushing crews make connection with these 1⅞-in. inside diameter outlets. All of the city street flushing or street sweeping equipment is provided with special 1⅞-in. connections, thereby making it impossible for them to connect to the regular 2½-in. fire hydrant outlet. This plan, while placing a burden of expense on the company, has been of immeasurable value in safeguarding the good working condition of the public fire hydrants.

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The Cause of Certain Weather Anomalies

ONE of the most puzzling features about rainfall has been the fact that in years when certain areas in the northern hemisphere are supernormal others are subnormal in rainfall. However, the riddle may be solved by the electron theory, provided that that theory is used to explain the existence of the permanent cyclonic and anticyclonic whirls.

Turn to Encyclopedia Britannica, under Climate, and you will see six permanent anticyclone areas near the tropics, three north of the equator and three south of it. These are areas of high barometric pressure, due to the fact that the whirling air is descending. North of the equator the three permanent anticyclones are rotating clockwise, whereas the three south of the equator are rotating anticlockwise. Note that their centers are about 120 degs. apart in longitude. Note also that there are two very pronounced permanent cyclones, rotating anticlockwise, one having its center in Bering Sea, near Alaska, and one near Iceland. Then observe that two of the great anticyclones lie almost south, but slightly to the east of these arctic cyclones. This raises the thought that each of these anticyclones may be the tail end of a cyclone to the north. The Alaskan cyclonic whirl apparently ascends, bends over and descends as the anticyclone in the Pacific between Hawaii and California. There are several facts that support this inference, notably the fact that at times when the Alaskan whirl is strongest, the north Pacific whirl is strongest and has its center farthest south. It is significant also that sunspots, similarly occur in pairs that are rotating in opposite directions.

By aid of topographical uplifts that lie on the arcs of circles, the editor has inferred that there are 13 great cyclonic whirl-belts of molten matter whose centers were nearly stationary during the uplift of such arcs as the Aleutian Islands, the southwest coast of Greenland, the north and northwest coasts of South America and Africa, the arc-like string of islands starting with Sumatra, etc. The evidence is strong that many of these molten-whirls still exist, and that above them there are permanent cyclonic whirls in the air. The electron theory suffices to explain all such whirl-belts in fluids, as well as to explain the rather symmetrical arrangement and the relative permanence of the whirl centers.

Since electrons are known to cause condensation of atmospheric moisture, the basis of a complete theory of air circulation and rainfall is thus furnished. Since cyclonic whirls in the northern hemisphere are opposed in direction to those in the southern hemisphere, it follows that they must have opposite magnetic polarity if they are caused by electrons revolving in orbits about the whirl centers. Being opposite in magnetism they would be oppositely affected by any external magnetic field, such as that of the sun or a sunspot or a planet. This explains why the seasonal precipitation near the arctic circle reaches its maximum when it is a minimum near the antarctic circle, and vice versa; and it explains other similar differences in those two hemispheres. But it does not explain why India may have a drought during a year when California has excessive rainfall. If California receives an increment in electron density from the Alaskan cyclone, it receives increased rainfall. But if the anticyclone in the Indian Ocean moves farther away from its cyclonic source whose center is near the Philippine Islands, then the customary summer monsoons due to that anticyclone fail to be as strong as usual, and less moist, air sweeps over India, resulting in deficient rainfall. Similarly the shifting of the anticyclone whose cyclonic origin is in Africa affects the summer rainfall in the region of the Gulf of Mexico and our southern and central states.

Remembering that the Arctic Circle permanent cyclones are strongest about the end of September, whereas those near the Tropic of Cancer are strongest about March, it is easy to see why a summer drought in the Gulf of Mexico region may be followed by a supernormal winter precipitation in America.

Certain meteorologists have objected to the theory that solar or planetary magnetism affects our weather on the ground that it should affect the entire world alike. To begin with such an argument fails to take into consideration the opposite magnetic polarity of the north and south hemispheres; but of equal importance is the failure to recognize the fact that the earth is a compound magnet, and that its Heaviside layer of electrons, in the upper atmosphere is probably a compound magnet also; under the influence of these lower and upper magnetic fields, and of the magnetic fields due to the sun and planets, the electron density varies in the earth's atmosphere because of electron migrations. Winds and rainfall, being primarily due to atmospheric electrons, consequently vary in a systematic and understandable manner.

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Financing Water Works Extensions and Improvements Out of Revenues

THE gasoline tax has become the most popular method of securing money with which to build roads. Every state in the Union now has such a tax. Formerly many a bond issue for road improvement was voted down not because such improvements were not needed, but because taxpayers usually dislike incurring a large indebtedness. Now the same taxpayers willingly finance enormous highway projects every year by means of taxes on gasoline.

Reasoning by analogy it seems probable that desirable

enlargements, extensions and improvements of waterworks systems could be effected by slightly increasing present water rates. Many of the most successful industrial companies make it their practice to finance practically all their additions to plant out of earnings. Ford is a striking example of the success of this method of financing improvements. Not a few city water departments have successfully practiced the same business policy. But seldom have water rates been high enough to furnish capital sufficient for all additions and improvements.

In many instances water bond issues have been voted down. Yet in those very instances there is little doubt that a 10 per cent increase in water rates would have been accepted without protest, had it been proposed to use the revenue thus derived for waterworks improvements and extensions. We therefore urge serious consideration of this plan, not only where bond issues have been, or are likely to be, rejected, but as a permanent policy in all growing cities, namely the plan of raising water rates sufficiently to provide a substantial part of the funds needed for additional plant and equipment.

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Certain Illogical Inferences as to Rain Cycles

NOT four years ago a distinguished hydraulic engineer not only denied the existence of any evidence of rain cycles in precipitation, but went so far as to say: "No one can foretell when the next very wet climatic year or group of wet years will occur. There is no possibility of any forecast thereof by the use of sunspot or any other cycles." It is this last sentence that we propose discussing briefly.

In the words of Galileo: "Who is willing to set limits to the human intellect?" The hydraulic engineer just referred to has published a sentence that virtually answers Galileo by saying: "I am willing to set limits to the human intellect."

Speaking of this very problem of weather cycles, Prof. Karl Pearson, in his "Grammar of Science," p. 105, says: "If we believe in the capacity of the reflective faculty for ultimately reducing to a brief formula or law all types of phenomena, if we believe in the co-ordination of perception and reflection, then the weather will not probably appear a very strong argument against our hypothesis. It must at least be confessed that the discovery of a hundred or a five hundred years' period in weather would sadly discomfort those who delight in assuming that some one group of perceptions at least must be beyond the analysis of the reflective faculty. Yet such a discovery would not now be more remarkable than that of the Chaldean Saros or eclipse period must have been to those who looked upon eclipses as an arbitrary interference with their perceptions, and prayed and drummed vigorously for a restoration of the light of sun or moon."

Few meteorologists publicly deny the possibility of long range weather forecasting, but most of them seem to regard it as an achievement possible only in the far distant future. One of the most eminent of them has recently said that hundreds of years more of gathering of weather data will probably be required before long range forecasting will be feasible. Logically such a statement has no more foundation than has the statement that reliable long range weather forecasting will never be possible. Who can prove the insufficiency of existing data? The argument of insufficient data is apt to be the excuse of the man who has either never tried to discover a scientific law or who has failed in his attempt.

Clayton, in his "World Weather," p. 378, gives a composite curve formed by combining 10 different but harmonic curves that are cyclic. And then he shows how a computer analyzed this composite curve into its 10 distinct cycles, by using a method analogous to Schuster's periodogram method. He says: "This curve, though drawn from the summation of only 10 harmonic periods, appears to be absolutely fortuitous, yet the analysis of the data (i. e., the composite curve) by a person who did not know the number, or length of the periods from which it was constructed gave the results in the table." The results in that table show that, for 9 out of the 10 periods, the deduced length of each period was within 3 per cent of its actual length. In the 10th case the analyst erred 18 per cent.

Careful inspection of Clayton's composite curve does not disclose a single one of the 10 cycles. It appears to be completely haphazard in its ups and downs, thus resembling many a rainfall curve. None the less it is not a fortuitous curve that Clayton has plotted. By what reasoning process, then, has any engineer or meteorologist come to the conclusion that rainfall curves are either fortuitous or not susceptible of analysis until vastly more data are available? Apparently such conclusions rest upon the false premise that rainfall cycles are so few in number and so pronounced in effect, that they must be discoverable by mere inspection or the simplest of analytical methods.

The editor has discovered, and in several cases rediscovered, more than 20 rainfall cycles. Many of these would have remained hidden had he not used the cyclogram method of analysis devised by Balfour Stewart, the great Scotch physicist. Schuster attempted to improve on the cyclogram with his periodogram, but the periodogram introduces the hypothesis that all the cycles are harmonic, which is not the case. Each planet causes three harmonic cycles of rainfall, and all rain cycles are roughly harmonic, but an assumption of perfect harmony for all of them is disastrous in any weather research. Indeed, the attempt to force all the cycles into perfect harmony or commensurability is apparently at the bottom of most of the failures to unsnarl the weather snarl. In addition to this, there is a confusion oscillation of the length of each weather cycle about a mean length, due not only to the eccentricity of the orbit of each planet whose magnetism affects our weather, but to the orbital motion of the earth itself. The earth is a moving target and the planets are moving gunboats firing magnetic rays at this moving target. But let the complexity be what it may, an analysis of each cycle is practicable. Then a subsequent synthesis will undoubtedly fit the rainfall curves with considerable accuracy.

H. P. Gillette

Raw Water Aeration at Danville, Va.

By HOWARD A. JOHNSON
Superintendent of Filtration, Danville, Va.

DANVILLE'S, Virginia's first pretense at a water system, was put into operation during the year 1881. This was nothing more or less than a steam pumping station on the banks of Dan River about a mile below the site of the present water purification plant, the system depending on a steam pump for the quantity of water and on household filters for the quality of the water.

Early Filtration Plant.—During the years 1904 and 1905 this pumping station was abandoned for a then modern filtration plant at the present site. This plant had a maximum capacity of 3 m.g.d. The plant at that time consisted of the following: ½ m.g.d. settling basin, 6 tub filters, and a 3 m.g.d. Snow steam pump. The raw water being dosed by means of solution feed and flowing by gravity directly into the coagulation basins. With very few changes this plant supplied the demands of the city until 1924. By 1924 the consumption of water had practically reached the capacity of the plant, with a small margin of safety, and it had become somewhat obsolete and inefficient.

Plant Rebuilt in 1924.—During 1924 this plant was practically entirely rebuilt under the engineering supervision of Hazen and Whipple, and increased to a maximum capacity of 6 m.g.d.

At this time the coagulation basins were enlarged from a capacity of ½ m.g.d. to a capacity of 1¼ m.g. Raw water aeration was introduced, two dry feed machines installed for feeding aluminum sulphate, a circular mixer constructed to insure proper mixing of the chemicals with water, the 6 tub filters replaced by 8 ¾ m.g.d. rapid sand filters with a total filter area of 1,724 sq. ft. or 215.5 sq. ft. per unit, a low lift raw water pump installed, and an electric high lift pump substituted for the steam pump, reserving the steam pump as an emergency standby unit.

The old plant received its water from the river by gravity, but on the enlargement of the plant it was necessary to install a low lift pump to supply the aerator and also to take care of the increase demand on the raw water line.

The Filters.—The rapid sand filters were constructed with a great deal of ingenuity and simplicity, mainly to cut down the cost of construction. All the 8 filters are operated practically as one filter in two banks, being controlled by one rate of flow gage and one loss of head gage. Each bank of 4 filters is supplied by one influent valve and drained by one drain valve. No re-wash valves were used. The effluents from the 8 filters are controlled by separate valves; thereby arranging for washing each of the 8 filters separately; although each bank of 4 filters must be drained preparatory to washing, simultaneously.

The wash water is supplied by means of an eductor, obtaining one-third of its water from the distribution reservoir and two-thirds of its water from the clear well at the plant. This gives a constant rate of wash of 26 in. per minute, which may be lowered but not raised.

The raw water aerator removes practically 80 per cent of the increase in CO_2 content due to the application of the coagulant. The remaining CO_2 is removed after filtration by the application of caustic soda, which in turn is controlled so as to leave the water with a phenol alkalinity of approximately 1 p.p.m. and a pH of around 8.3. Chlorination is accomplished by the use of two Type M.S.V. Wallace & Tiernan vacuum feed chlorinators.

The water is lifted to the distribution reservoirs by means of a 5 m.g.d. centrifugal pump powered by a 2,200 V. G. E. synchronous motor. A 2½ m.g.d. centrifugal pump, powered by a 2,200 V. induction motor, and the 3 m.g.d. steam pump constitute the auxiliary pumping equipment.

When the plant was remodeled and modernized in 1924 an aerator was installed prior to the coagulating basins. The aerator receives the dosed raw water supplied by a 5 m.g.d. centrifugal pump powered by a 2,200 V. G. E. induction motor operating under a head of 14 ft.

Pre-aeration was deemed advisable for several specific reasons: To promote coagulation, to improve the efficiency of filtration, to remove possible tastes and odors, and to aid in the reduction of CO_2 present in the water.

The Aerator.—The dosed water supplied by the low lift pump is diffused by 37 nozzles each with a $1\frac{3}{16}$ in. orifice, falling onto a floor space of 1,600 sq. ft. or 320 sq. feet per m.g.d. As stated before, this aerator removes approximately 80 per cent of the increase in CO_2 due to the dosing with aluminum sulphate, which in turn raises the pH value and delivers the water to the coagulation basins with practically the same CO_2 content as that of the raw water.

The raw water enters the plant with a CO_2 content of 1½ to 4 p.p.m. and a pH value of 6.8 to 7.2, depending on the condition of the river. Dosing increases the CO_2 content to from 2 and up depending on the amount of coagulant used. Aeration in turn lowers the CO_2 content to approximately that of the raw water.

Since the installation of pre-aeration a decided improvement in the coagulation has been noticed and a slight decrease in the alum consumption in grains per gallon.

Except in rare cases, and then for only a short period of time, it is now unnecessary to use an alkali to obtain the desired floc (soda ash being used when necessary) while before the installation of the aerator an alkali (lime being used at that time) was necessary practically at all times.

From the aerator floor the water flows by gravity, through the mixer to the remainder of the plant.

The following figures may be of interest relative to the plant as a whole:

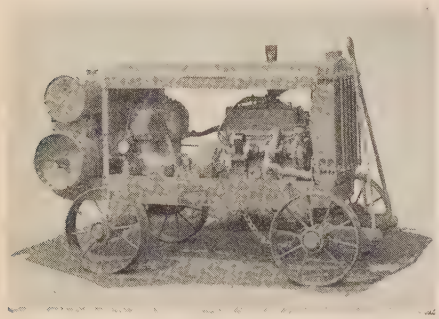
Number of filters	8
Filters areas (total)	1,724 sq. ft.
Capacity (maximum)	6 m.g.d.
Storage:	
Plant reservoir	0.5 m.g.
Distribution reservoirs	7.5 m.g.
Total	8.0 m.g.
Net capacity (computed)	4.69 m.g.d.
Net capacity	78.2 per cent
Filter yield	44 m.g. acre day
Rate of filtration	117 m.g. acre day

Acknowledgment—The foregoing is a paper presented at the annual meeting of the Virginia Water and Sewage Works Association.

New Equipment and Materials

Schramm Engine-Driven Compressor

The standard No. 72 Schramm compressor is a complete engine-driven unit embodying all the features found in larger Schramm outfits, and has a displacement of 72 cu. ft.



Schramm No. 72 Portable Engine-Driven Compressor

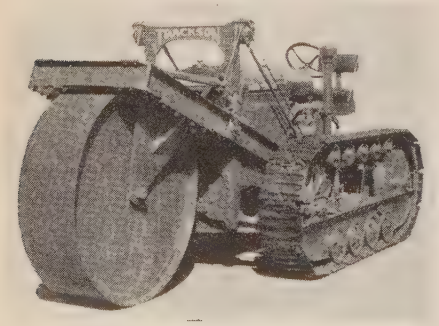
This size of compressor serves many purposes. First, it can be used as an auxiliary unit for replacing the larger compressors on work where only a one-tool outfit is needed; and second, it makes a good investment for the contractors who need only a small outfit for the occasional rock drilling, paving breaking, demolition work, clay digging, tamping, riveting and other work done by pneumatic tools on their jobs.

The outfit is completely housed with removable steel doors and equipped with extra-heavy A. S. M. E. riveted tank with fusible plugs, directly connected to the compressor by means of a heavy pipe with rugged expansion joints. The tanks are inspected and carry with them a certificate of inspection.

New Trackson Trench Roller

An interesting recent development in construction equipment is the new Trackson trench roller, illustrated here, which provides a simple, effective and economical method of packing down dirt over newly-laid cable, conduit or pipe line. This roller is manufactured by the Trackson Co., Milwaukee, Wis.

This roller is built for mounting on the Model DH Trackson McCormick-Deering crawler-tractor, as shown in the illustration. It consists of a wide steel roller filled with concrete, which weighs from 3,000 to 4,000 lb., the weight varying to meet the requirements of different soil conditions. For average jobs a 3,500-lb. roller is recommended.



Trackson Trench Roller

Interchangeability is a feature of Trackson front-end tractor equipment, and since the mechanical hoisting assembly of the trench roller is identical with that of the Trackson shovel and the Trackson bulldozer, it is an easy matter to detach any one of these attachments and mount another in its place. In this way a single power unit may be used for a number of purposes.

This outfit may be used for rolling over all kinds of underground lines without damaging the cable or casing, provided, of course, that sufficient dirt is thrown over the pipe before it is rolled. The first layer should be from 10 to 20 in. in depth, depending on the nature of the soil, and the rest of the dirt is usually rolled in 6-in. layers.

New ½-Yd. Convertible Excavator by Orton

A new small excavator has been developed recently by the Orton Crane & Shovel Co., Chicago, Ill. It is equipped with a 40-hp., 4-cylinder gasoline engine which is provided with an accelerator arranged for both hand and foot operation, electric starter, oil filter, air cleaner and other modern accessories.

New Orton Model 4 Excavator

Power is transmitted by means of a multiple-disc clutch, the transmission shaft being mounted on anti-friction bearings. Connecting the transmission shaft to the propelling clutch shaft is an enclosed alloy-steel chain with floating take-up. By use of the engine clutch the double-jaw propelling clutches can be shifted as easily as a friction clutch of the gear type, and the traveling speed can be varied from ⅝ to 3 m.p.h. A special main cutout clutch enables the operator to stop all of the machinery except the propelling mechanism when traveling, a decided advantage when going any considerable distance.

The treads are of the self-cleaning type, and are driven by heat-treated alloy-steel roller chains on large-diameter hardened sprockets, provision being made for take-up of both the treads and chains. Coil springs back up each set of treads, thus protecting the operating mechanism from undue strains and shocks, and distributing the weight of the machine uniformly on the shoes when traveling over uneven ground.

Steering is accomplished by a hand wheel in the cab, brakes being applied to either of the two differential shafts. The machine can be turned in a circle, the radius of which is equal to the center-to-center distance between the treads.

The shovel is equipped with a 16-ft. heavily-constructed and electrically-welded boom and a 12½-ft. electrically-welded dipper stick with numerous diaphragms. A special patented rope crowd does away with troubles incident to the adjustment of the length of the rope, and the dipper can be held in a fully extended position. Normal speed of the crowd is 85 ft. per minute.

The Model 4 excavator is readily convertible to shovel, crane, dragline, ditcher or skimmer, and changes to these attachments can be made in the field.

An extension of the cab for the operator's position gives a clear view of the work on both sides of the machine, and the levers are conveniently located. Each function of the Model 4 is controlled by a separate lever.

The Cranemobile

A new convertible machine—the "Cranemobile"—is now in production by Bay City Shovels, Inc., Bay City. Mich.

The Cranemobile is an adaptation of the Bay City crawler mounted tractor model. No change is made in the machinery, superstructure or booms and buckets. In place of crawlers heavy steel wheels with large solid rubber tires are substituted permitting faster travel speeds and eliminating crawler wear for long or fast moves. A special heavy duty forged Timken front axle is provided with roller bearings. Steering mechanism is provided under tractor end of machine. The Cranemobile is intended for any material handling job where a truck crane would normally be used or where a fast moving and operating machine is desired for work on hard or relatively smooth ground.

The tractor shovel is to be continued in production, as the Cranemobile is intended for another field of work, where hard surfaces conditions favor a rubber wheel mounted machine, rather than crawlers.

This machine is convertible and, in addition to standard crane attachments, such as clamshell, hook and block, electric magnet, etc., it is available with shovel dipper, trench hoe or skimmer bucket.

Three speeds forward up to seven miles an hour and one speed reverse are available.

Bay City Cranemobile

WATER & WORKS SEWERAGE

Design~Construction~Collection
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December, 1930 — W. P. Gillette Editor — Vol. LXXVII. No. 12

High Service Pump Room at New Water Softening and Filtration Plant of Cedar Rapids, Ia.

MEMBER A. B. C.—A. B. P

City Health Means Pure City Water *and* Treated Sewage

Health, in these city-building days, is closely allied with adequate public sanitation; and to the official who knows, the better part of this sanitation is *pure water and scientific sewage disposal.*

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Water Works and Sewerage

H. P. GILLETTE, Editor

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Water Works and Sewerage

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Main Pumping and Filtration Building of Cedar Rapids, Ia.

New Water Softening and Filtration Plant of Cedar Rapids, Ia.

By L. R. HOWSON

Alvord, Burdick & Howson, Consulting Engineers, Chicago, Ill.

IN the summer of 1928, engineers were employed to make a comprehensive investigation and report upon all the water supply resources available to the City of Cedar Rapids, Ia., with instructions to place these supplies on comparable bases as to the character of the supply, cost of development and the annual cost, including operation and fixed charges.

All sources were compared as to adequacy for present needs and capability of future enlargement, the cost development, annual cost, including operation and fixed charges on required expenditures, hardness, temperature, freedom from taste and odors and sanitary quality.

In considering the question of adequacy, it was necessary to make a study of population growth, past, present and probable future. The present population of approximately 55,000 people was estimated to be 75,000 in 1940 and 170,000 by 1970.

Based upon the forecast of population and a detailed study of the statistics for the past 25 years covering the population, services, people per service and gallons of water used per service and per capita, a forecast of water requirements was made the results of which indicated that the present average daily use of about 4½ million gallons would increase to approximately 6½ million gallons on an average day in 1940 with maximum day's use at that time reaching 11.2 million gallons per day. 1940 conditions were used in all cases as the basis for present construction.

All of the available sources of supply yield relatively hard waters and softening would be advisable with any one. All estimates and comparisons were therefore based on softening to about 4 grains per gallon or somewhat less than one-half the average hardness of the old filtered river supply.

Filtered, Softened Cedar River Supply Recommended. —As an outgrowth of this investigation, it was recommended that the city proceed to develop the Cedar River supply, filtered and softened using electricity for pump-

Filter Operating Gallery of the Recently Completed Water Softening and Filtration Plant of Cedar Rapids, Ia.

ing. The abandonment of the existing plant was recommended, together with the construction of a modern plant to be built on the east bank of the Cedar River well upstream from the city. A suitable location was indicated approximately opposite Ellis Park. It was estimated that the total expenditure, exclusive of land, would be $640,000.

The program recommended was submitted to the voters and carried by a large majority. The engineers were instructed to prepare plans and specifications and bids were taken in the early summer of 1929. Work proceeded at a good rate and the plant was completed and ready for operation in the late summer of 1930.

The New Water Works.—The new construction embraces a low lift pumping station located on the east bank of Cedar River at a point some 2 miles upstream from the center of the city and 4,500 ft. upstream from the main purification plant and high lift pumping station.

The low lift pumps discharge into a 30 in. cast iron force main connecting the low lift with the high service plant. The high service plant includes mixing facilities, sedimentation and recarbonation basins, mechanical filters and an electric driven high service pumping station whose pumps discharge into mains connecting with the present distribution system of the city and the 8 million gallon high service reservoir.

Low Lift Station.—The low lift station is of the automatic remote control type. The water enters the station through two 36 in. cast iron intakes, extending out into the river and in approximately 6 ft. of water. The pipes are anchored to piling and protected by rock embankment. The intakes terminate at the shore end in a screen and suction well equipped with iron bar screens having 1½ in. clear opening. The pump suctions are turned into this well, the bottom of which is approximately 11 ft. below the ordinary water surface in the river.

The low lift pumping equipment consists of: one 5 m.g.d. motor centrifugal pump, one 7.5 m.g.d. motor centrifugal pump, and one 10.0 m.g.d. combined motor and gasoline engine driven unit. The pumping installation is so designed that the entire operations may be controlled from the station panel in the high lift station approximately 4,500 ft. distant. The sequence of operations for remote control is as follows:

Pressing the "start" button for the low lift will start the priming pump and open the solenoid valve in the priming line of the unit to be started. When the unit is primed and water has risen into the float chamber of the float switch above the pump casing, the low lift pump control is actuated by the float switch. The pressure developed in the pump discharge line after the unit is up to speed, stops the priming pump. Pressing of the "stop" button in the main station shuts down the low lift pump.

The control equipment provides protection for the low lift equipment in case of abnormal conditions such as failure of the low lift pump to prime, the loss of suction or discharge pressure in the low lift station, the overheating of the motor winding, the occurence of under voltage conditions of less than 75 per cent of normal for one minute or the flooding of the low lift pump pit.

The building is heated by a thermostatically controlled, oil burner fired, pipeless furnace.

Aeration.—At rather infrequent times, the river water carries taste and odors. Areation is provided. This will be supplemented at a later date if necessary by the

adoption of one of the taste and odor removal or prevention processes which are now being developed and demonstrated.

The areation is through nozzles of the "Sprayco" type, each having a discharge capacity of 115 gal. per minute at 15 ft. head. These nozzles are attached to a header running entirely around the mixing chambers into which the water falls after aeration.

Chemical Facilities.—Chemicals are received at the plant in bulk in carload lots. They are unloaded from the cars by a vacuum unloading system having a capacity of 7½ tons per hour. The materials are discharged into a hood in which the air is separated from the chemicals, the latter discharging through a hopper on to a 9 in. spiral conveyor 32 ft. in length which carries the chemical to any one of three steel storage bins. These bins are 12 ft. in diameter with an average height of 24 ft. and have a total storage capacity of approximately 180 tons. Two will ordinarily be used for lime and one for alum.

Four chemical feeders are provided, two for lime, each having capacity of from 50 to 1,000 lb. per hour. These feeders will handle either pulverized or lump materials. Two other feeders are provided to handle pulverized alum, lime or soda-ash, their capacities being adjustable from 10 to 500 lb. per hour.

The lime machines are equipped with slackers and the alum machines with dissolving boxes.

Mixing Facilities.—The design of the plant provided for a rapid agitation and mixing of the chemicals with the water in what are termed pre-mixing basins, having a storage period of approximately two minutes, the agitation being provided by change in direction of flow supplemented by air discharge through perforated pipes in the bottom of the basins. Air compressor capacity of 50 cu. ft. per minute is provided.

From the pre-mixers, the water with the chemicals passes to two mechanically operated stirring basins, each with a capacity for 30 minutes detention.

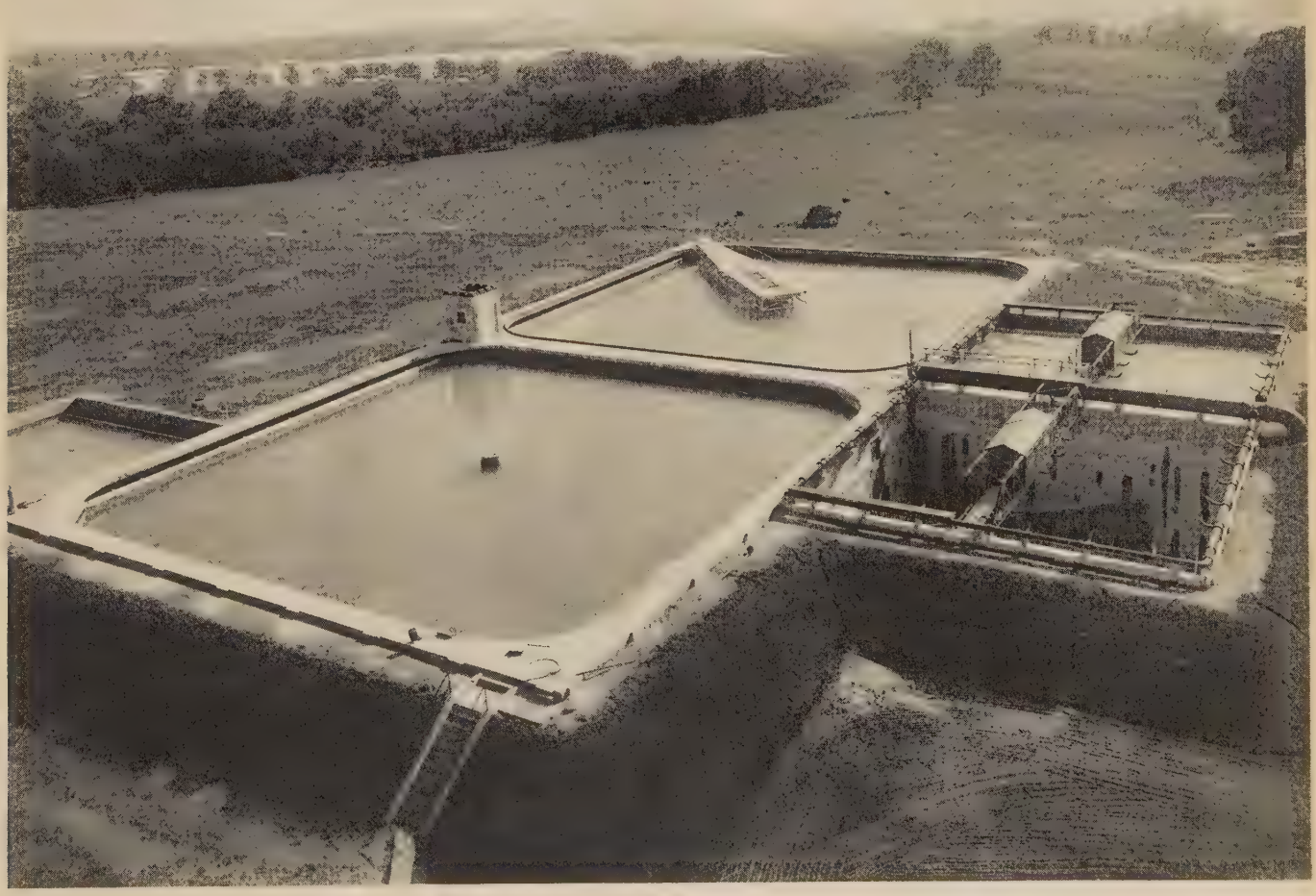
The basins are 50 ft. square by 22 ft. deep. The stirring mechanism consists of vertical shaft with two extension arms to each of which are attached six steel plates which drag through and stir the water after the chemicals have been thoroughly mixed with it in the premixers. The plates swing loosely on the arms to prevent excessive starting load on the motor.

The water enters the mixing basins tangentially at the bottom and leaves at the top. The mechanism is operated by a 5 h.p. motor.

Clarifier and Settling Basin.—The mixing or re-action basins are followed by two settling basins, each having a capacity of 2 hours at rated plant capacity. One of these basins is now equipped with Dorr clarifier. Provision is made for installing similar mechanism in the second tank at a later date. The mechanism installed is of the Dorr traction type.

The plans contemplated a low brick superstructure with wood roof over the mixing and settling tanks. Funds were not available for their construction at this time. The anchor bolts, lighting conduits all were installed with the future superstructure in view.

Series vs. Parallel Operation.—The plant is so ar-



Mixing, Clarifier and Carbonating Basins

ranged, on account of the variable character of the raw water, as to permit of either parallel of series mixing and settling. The plant will ordinarily be operated in series, but the sequence of chemical feeding will depend upon the character of the raw water.

Ordinarily when the turbidity is relatively low its removal will be incidental to the softening treatment. At such times the order of operation will be to apply the lime in the first pre-mixer thence pass successively through the first mixing or reaction tank, the first clarifier the lower section of the bypass conduit in which it will be given CO_2 and returned to pre-mixer No. 2 for the alum dosage before passing through the second reaction chamber and the plain settling basin. It will then be recarbonated and pass to the filters.

At times of high turbidity the order of application of chemicals will be reversed so as to precipitate out the turbidity before softening. The water then will first be dosed with alum, then flow from the first pre-mixer to the first mechanically stirred re-action basin, and thence to the first clarifier where the turbidity will be largely removed. The settled water will then return to the second pre-mixing tank for its lime dosage, thence to the second settling basin followed by recarbonation before going to the filters.

Series operation will be the normal operation on account of the practicability of using returned sludge from the first basin and thus securing somewhat better softening operations. Preliminary operations indicate a marked reduction in hardness by series over parallel operation. Operations to date have produced a water with about 3 1/3 grains hardness and with but two grains of carbonate hardness remaining. Lime alone has been used for softening with clarification assisted by feeding ½ grain of alum.

Carbonation.—The water is recarbonated using CO_2 generated by an oil burner under a boiler. The boiler is cross-connected with the heating system so that the heat generated will be used in heating the buildings during the winter months. During the summer, the steam generated will necessarily be wasted.

The gasses from combustion pass through a scrubber for cleansing and cooling and are then compressed under approximately 12 ft. head of water and discharged through a galvanized pipe grillage located in the bottom of the carbonating basin. The carbonating basin has a detention capacity of 20 minutes at the rated capacity of the plan. The CO_2 piping laterals are ¾ in. in diameter and have 1/16 in. holes spaced at 24 in. centers.

Filters.—After carbonation, the water passes to the mechanical gravity filters. The filters are in four units each of 3 million gallons per day at standard water works rating of 2 gal. per square foot per minute. Each filter bed is in effect two filters, separated by a central gullet, the upper part of which takes the dirty wash water and the lower part being the effluent channel and the wash water distributer. The filters contain 30 in. of sand specified has having an effective size of .36 to .55 m.m. and a uniformity co-efficient of 1.3 to 1.6. The sand overlies a gravel bed of a total depth of 21 in. over the center line of the laterals. The gravel is placed in 4 carefully graded layers.

Each filter has four 9 in. x 12 in. C. I. headers, each feeding 52.2 in. C. I. laterals having ⅜ in. holes at 6 in. centers.

The pipe gallery is commodious and piping so arranged as to provide ample walkways and room for removal or repairs of equipment. All valves are hydraulically operated and provided with cast iron bronze lined cylinders. The main influent channel and the sewer are of reinforced concrete. All other conduits in the pipe gallery are of cast iron. . The filter equipment was installed by the International Filter Co. of Chicago, who also installed the pumping equipment, piping inside the station, mechanical agitators, etc.

The filters discharge into a clear well directly underneath, having a capacity of 600,000 gal. The clear well is in effect a two compartment suction reservoir for the high lift pumping equipment, which discharges directly into the distribution system on which floats an elevated storage reservoir of 8 million gallons capacity advantageously located in the city.

High Lift Pumping Equipment.—The high lift pumping equipment consists of 3 units as follows:

One 4.5 m.g.d. combined electric and gasoline engine unit, one 7.5 m.g.d electric motor centrifugal unit, one 10.0 m.g.d. electric motor centrifugal unit.

The pumps take a suction directly from an open channel running under the pump room floor and connecting directly to each of the two compartments into which the clear well is subdivided. All motors throughout the plant are of the synchronous type. All pumping equipment was furnished by the American Well Works of Aurora, Ill. Control equipment is Westinghouse with all installation wiring, etc., by the Robertson Electric Co. of Cedar Rapids. The gasoline engine units are driven by Sterling high speed gas engines with rating established at not to exceed 1,250 r.p.m.

Wash Water Tank.—Wash water for the filters is secured from a 100,000 gal. wash water tank located in the tower of the building.

The Building.—The building is of the Gothic type with brickwork selected to match the stone trim, giving the building when viewed from a distance the appearance of being constructed of stone.

The interior arrangement was designed so as to facilitate operations and reduce the operating personnel to a minimum. All operations from chemical feeding, pumping and filtration, are connected through an operating gallery. The laboratory and office are located near the center of operations.

Personnel. — The preliminary investigations, the preparation of detailed plans and specifications and the supervision of construction were under the direction of Alvord, Burdick & Howson, consulting engineers of Chicago. The engineers associated with them were Mr. Victor A. Matteson as architect and Mr. Charles P. Hoover of Columbus, Ohio, as consulting chemist. The pipe lines and certain exterior work were executed by Mr. H. F. Blomquist, superintendent of the Cedar Rapids water works. The Stark Construction Company of Cedar Rapids were general contractors.

Acknowledgment.—The foregoing is an abstract of a paper presented Nov. 5 before the Missouri Valley section of the American Water Works Association.

NEW WATER RATES FOR IOLA, KAN.—The following rates have been established for the municipal water works of Iola, Kan.:

First 500 cu. ft., 25 ct. per hundred.
Next 500 cu. ft., 25 ct. per hundred.
Next 1,000 cu. ft., 18 ct. per hundred.
Next 4,000 cu. ft., 12 ct. per hundred.
Next 10,000 cu. ft., 10 ct. per hundred.
Next 20,000 cu. ft., 8 ct. per hundred.
Excess, 6 ct. per hundred.
Minimum monthly bill, $1, which shall include not to exceed 400 cu. ft.

The Benefits of Liming an Imhoff Tank

A Foaming Imhoff Tank Handling a Domestic Sewage and Lime Treatment Are Discussed—Frequent pH Determinations of the Sludge from the Imhoff Tank to Ascertain Its Effectiveness Are Recommended

By H. C. BRILL and C. W. KREGER
Department of Chemistry, Miami University, Oxford, O.

IN the month of January, 1929, the village of Oxford, O., put into operation a sewage disposal plant of the Imhoff type, consisting of a grit chamber, Imhoff tank, with an approximate capacity of 250,000 gal., a dosing tank, trickling filters, a humus tank and sludge beds. The Imhoff tank was not inoculated and the operation of the plant was initiated in January.

Abrupt Changes in Sewage Volume.—Oxford is a village of 2,300 inhabitants and a student population during the regular school periods of nearly 3,000 more. (Miami University—enrollment 2,300, Western College for Women—500.) Thus the numbers whom this plant must serve are approximately 5,300 from the middle of September to the middle of June; 3,000 from the middle of June until the first of August; and 2,500 from then until the middle of September. (There is a six weeks' period of summer school enrollment—700, followed by a five weeks' period with an enrollment of 300 at Miami.) Thus there are several extremely abrupt changes in the population of the village during a calendar year which account for abrupt changes in the volume and concentration of the sewage. Oxford is a typical college town with no industries, consequently there is no industrial waste in the sewage—it is of a typically domestic type.

Early Operation Without Technical Control.—Despite the fact that this plant was started in January, during the season when the organisms are least active, because of the low temperature of the sewage, and at the time when the raw sewage flow of the village is greatest, and without inoculation, no difficulties were encountered until the following August, after the plant had been operated long enough to accumulate sufficient ripened sludge, also when the flow was least and the temperature highest, therefore the organisms most active. During this period the plant had operated without technical control due to a misunderstanding between the village authorities and the constructing engineers. During August, 1929, gassing began. Ripened sludge had been withdrawn from the Imhoff tanks to the drying beds but the ratio between the ripened sludge that remained and the solids in the raw sewage was favorable. This gassing continued, gradually becoming more severe until around the first of October (schools were in session and the village had its maximum population) when it became so difficult to control that the authors were consulted and their services engaged.

An examination showed that the pH of the Imhoff sludge was low, being 6.8; the odor of the sludge was slightly tarry but noticeably objectionable; sedimentation was poor; gassing was so excessive that difficulty was experienced in keeping the foam from overflowing the gas tanks. The remainder of the plant seemed to be operating effectively, and the final effluent appeared to be excellent.

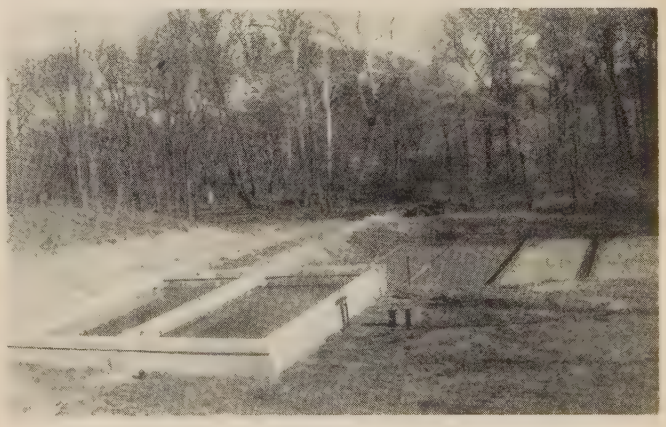
The First Liming.—On Oct. 2, 250 lb. of lime were added as milk of lime, being placed at the bottom of the sludge chamber by means of weighted buckets, and then thoroughly stirred. The following day the pH had risen to 7.4. Fifty pounds of lime were added. On Oct. 4, 5, and 6 when the pH rose to 7.3 and while foaming continued somewhat, though less severely, all the other characteristics had improved. Lime was added intermittently throughout the winter but the foaming had subsided within three weeks after the pH had been adjusted by means of the lime.

We have followed the practice of adjusting the pH by means of quick lime as soon as the sludge shows a tendency to maintain a pH of 7.1 or lower. When this method is followed very small amounts of base are needed to effect this change and no foaming has occurred since that time. Hatfield's[1] experience proves the hazards of allowing a tank to become too acid and of resting a tank so long that only old sludge with senile organisms is present. However, the sewage described by Hatfield is of a quite different character on account of the starch waste present and may require a different treatment and will undoubtedly respond markedly differently to the same treatment.

At no time has the final effluent been objectionable.

A scrutiny of the above data reveals the fact that after the first of November very little quick lime has

Imhoff Tank at Oxford, O., Plant



Final Settling Tanks and Sludge Beds at Bottom of Hill

Table I—Liming of Imhoff Tank

Dates	Amount of Lime—Pounds	Imhoff Effluent pH Before Liming	Imhoff Effluent pH After Liming
10/2/29	250	6.8	7.4
10/4-6/29	50 daily	7.0	7.3
10/18-24/29	25 daily	7.0	7.1
10/25-26/29	50 daily	7.1	7.3
11/1/29	50 daily	7.1	7.4
11/2-8/29	25 daily		
11/15-20/29	25 daily	7.2	7.5
1/10/30	100	6.9	7.5
1/22-23/30	25 daily	7.1	7.3
5/9-13/30	50 daily	7.0	7.2
6/4-9/30	25 daily	7.1	7.3

Table II—pH Values at Different Depths in Imhoff Tank

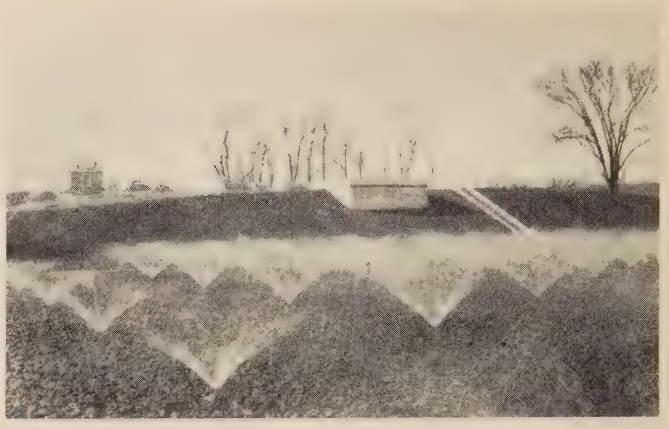
Date	Depths in Tank	pH
8/19/30	5 ft. above sludge line	7.1
	5 ft. below sludge line	7.1—
	Bottom of tank	7.4
8/26/30	5 ft. above sludge line	7.3
	5 ft. below sludge line	7.2—
	Bottom of tank	7.3
	Imhoff effluent	7.4

been needed to adjust and maintain a favorable pH. This base is usually added to the incoming raw sewage.

But we found that addition of lime to adjust the pH to a value above 7.1 will not correct the foaming—the alkalinity must be maintained—thus confirming the experience of Hatfield,[1] who found lime beneficial but expensive on account of the quantity required to maintain alkalinity, and Lackey,[2] who has observed that excessive numbers of protozoa are present when gassing occurs, that these numbers are increased by the initial addition of lime and that they decrease when the addition is regularly continued. Buswell[3] states that the maintenance of alkalinity usually results in benefit—though this benefit is not universal. Rudolph[4] is authority for the statement that the favorable pH for operation lies between 7 and 8. Coburn's[5] experience corroborates our practice. He relates the favorable results obtained by the judicious use of quick lime with a sewage of a character similar to that of Oxford.

Sludge pH Best Indication of Effective Working.—

Grit Chamber with Imhoff Tank in Background



Trickling Filters; Dosing Tanks Are in Hill Immediately Beyond Filter, Operator House in Background

We believe that the pH of the sludge is the best indication of the effective working of the Imhoff tank, and that a constant relative-to-the-sludge depth should be adopted for the taking of test samples. Samples taken from different depths do not give identical pH values and the Imhoff effluent is too easily influenced by the nature of the raw sewage that enters to warrant its use.

We believe that changes in the pH of the Imhoff tank can be most promptly detected by reasonably frequent determination of the pH of sludge taken from the top of the sludge in this tank.

In conclusion we wish to point out that when trouble arose with this plant (1) it had been in successful operation for seven months; (2) that the weather had been warm for four months directly antecedent to the gassing and that the condition was corrected before cold weather was experienced; (3) that excessive foaming began when the raw sewage volume was smallest for the year; (4) that the pH was low; (5) and that sludge had been drawn to the drying beds just previous to the onset, but the ratio of ripened sludge to solids in the raw sewage was satisfactory. Practically all these factors, except the low pH, are favorable to the continued successful operation of the plant.

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[1] Hatfield, Ind. Eng. Chem. 22, 173, (1930).
[2] New Jersey Ex. St. Bul. 427, pp. 38 and 98 (1925).
[3] Buswell, The Chemistry of Water and Sewage Treatment, Chem. Cat. Co. p. 260-4 (1928)
[4] Rudolph Proceedings 11th Annual Meeting, New Jersey Sewage Works Association, p. 24.
Rudolph, Public Works, 59:483 (1928).
[5] Coburn, Ind. Eng. Chem. 19, 235 (1927).

State and Municipal Borrowing in November

State and municipal bond flotations in 1930, will aggregate close to $1,500,000,000, according to an estimate made by The Daily Bond Buyer of New York, whose survey shows that the issues marketed during the eleven months of the current year amount to $1,286,219,500. For the corresponding period of last year, the total was $1,155,864,382.

The following table, prepared by The Daily Bond Buyer of New York, compares municipal bond sale totals in November for the past ten years:

	November	11 mo. ending November 30
1930	$ 93,784,008	$1,286,219.500
1929	65,974,063	1,155,864,382
1928	173,824,090	1,273.678,177
1927	105,067,010	1,359,866,596
1926	71,725,702	1,214,790,875
1925	71,522,706	1,238,429,540
1924	120,243,926	1,373,088,678
1923	132,167,398	1,037,820,494
1922	93,600,366	1,226,056,132
1921	121,487,608	1,069,623,024

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Physical Chemist, Bureau of Engineering, Chicago, Ill.

Watch for Flocculated Matter Passing the Filter Beds

Now is the time to watch your filtered water for flocculated matter passing the filter beds. As the water gets colder in the winter the strength of the flocculated matter decreases until finally when the temperature is near the freezing point the flocculation is quite weak. There are some, if not many waters, that contain enough reinforcing material so that there is little or no danger of flocculated matter passing the beds, but for the vast majority of waters where the temperature goes below about 4° C., flocculated matter penetrates quite deeply into the sand beds. It will begin to pass on through the beds in many plants if the loss of head is allowed to go high. In some plants such conditions of weak flocculation may occur only every few years.

The writer[1] has called attention to the weakness of the flocculated matter in the colder months and the danger of it passing through the filters. An instrument for detecting such matter in the filtered water also has been described. Flocculate matter passing the filter beds has not attracted the attention it should have attracted, and it is believed desirable to again call attention to the importance of watching the filtered water for flocculated matter, especially in the colder months.

Character of the Flocculated Matter that Passes the Filters.—The flocculated matter passing through the filter beds is nothing other than particles of the coagulated matter which are not removed by filtration. Usually they are broken into particles much finer than those observed leaving the settling basins to go to the filters. This is due to the large flocculated masses being forced through very small openings between the sand grains. If the filter bed has a loss of head of 6 to 8 ft., there is considerable pressure exerted in forcing the water through the numerous small openings through the sand beds. It is known that water overflowing the inlet or outlet baffle of a settling basin with a drop of only 3 to 4 in. will create sufficient turbulence to break up the larger particles of flocculated matter; now with a force of several feet head of water exerted upon the filter beds it is evident there is considerable force tending to break up the coagulated particles.

Why the Large Flocculated Particles Are Easily Broken Up into Smaller Particles.—In the June, 1930, issue of WATER WORKS AND SEWERAGE, the formation of the flocculated particles was explained. First there are numerous small particles of coagulated matter formed shortly after the addition of the coagulant, probably so small they cannot be seen without considerable magnification. The next step is the joining together of these small masses into larger masses, until finally the large flocculated particles are formed. It should be evident that the very large flocculated particles are easily broken up into smaller particles, for the union of the smaller particles to make large ones cannot take place so firmly that the large mass is of homogeneous strength. The rush of the water through the voids in the sand beds readily breaks up the large particles of flocculated matter into particles varying in size perhaps from about 0.01 mm. to 0.02 mm. diameter. These are the size particles that go through the filter beds most readily. They are coagulated particles just the same as that of any of the coagulated matter, and contain some of the entrapped impurities of the water such as mud, bacteria, microörganisms, etc. The broken up particles do not pass on through the sand beds just as soon as they are broken up at the surface, but there are at first filtered out. It is only after the sand voids become partially filled from the surface of the bed to near the gravel layer with coagulated particles that such particles begin to pass on through the bed to any material extent. The large particles of flocculated matter so desirable for good settling have little influence upon filtration, except that the fact the large particles are formed is an indication of the water being properly coagulated. The large flocculated particles might be broken up just prior to filtration without much effect upon the filtration.

Causes for the Weakness of Coagulated Matter.—In the same issue of WATER WORKS AND SEWERAGE to which reference was made in the previous paragraph, curves were shown of the loss of head and of the amount of coagulated matter passing the filter beds for water near the freezing temperature and water at room temperature. These curves showed that for water in which the coagulated matter began to pass at 2 ft. loss of head when the temperature was 1° C., none passes at 8 ft. loss of head when the temperature was near 20°. The two tests were on the same water, though not conducted exactly alike. This may have had a slight influence. The water at the low temperature was coagulated and settled in a filtration plant, whereas that for the higher temperature was coagulated and settled in the laboratory. Both waters were settled to give nearly the same flocculated turbidity applied to the filters. Temperature may not have been entirely responsible for the good results obtained at the high temperature as compared with that of the low temperature, but it was the major factor.

Water at a temperature of 1° C., which contains sufficient reinforcing material, may form a coagulation sufficiently strong so that it will not pass through the beds at 8 ft. loss of head, but the reason for this is the aid given by the suspended matter. Microörganisms, gelatinous compounds such as organic jellies, and even the turbidity itself, add strength to the flocculated mat-

[1]Significance and methods for determination of filter plant turbidities. Municipal News and Water Works, 76: 156-9, April, 1929.
Factors influencing the toughness of coagulated matter. Water Works and Sewerage, 77: 184-8, June, 1930.

ter. In some waters there is always enough of such materials to prevent the formation of very weak flocculation, whereas in other waters there is not enough of such materials. Especially is this true if the water is likely to be deficient in reinforcing material when the turbidity is low and the water is too cold for organic growths. Some waters may form very weak flocculation only occasionally, for under most conditions the suspended matter contains the necessary reinforcing materials.

Filters Will Not Handle High Flocculated Turbidity.—This might be illustrated by citing an instance that happened in a plant some years ago. The turbidity of the raw water increased to about 5,000. Under ordinary circumstances this should have produced a fairly tough flocculation, even though the water temperature was low. The water was coagulated perfectly, but the precipitate was so heavy it carried the fresh water going into the settling basins downward to near the bottom, and then it moved forward in a zone several feet thick near the bottom of the settling basins. The water near the surface in the basins, in which most of the flocculated matter had settled out and was fairly clear, moved in the opposite direction. In other words, the water was going into the basins at one end and out the other end, yet the water at the surface was flowing towards the entrance end instead of towards the outlet end. The water in the upper two-thirds of the basin was rolling over and over while the water containing the coagulated matter flower along near the bottom at a velocity too great for good sedimentation. As a result the flocculated turbidity going on to the filters ranged from about 500 to over 1,000. Flocculated matter went through the filters very readily, and before the loss of head reached 2 ft. The turbidity of the combined filtered water was in excess of 100.

After running the plant for about one day with such unsatisfactory results, fire hose were directed on the surface of one of the settling basins in such a manner as to make the water on the surface flow in the right direction. Within less than one-half hour after starting the hose the water coming from this settling basin was fairly clear, having a flocculated turbidity of perhaps less than 10. After washing the filters which this basin supplied, the water came from these filters perfectly clear and free from flocculated matter. Also these filters would run to approximately 8 ft. loss of head without passing any coagulated matter. The other basin continued to produce poor settling results and the filters which it supplied continued to pass large amounts of flocculated matter.

When the high amount of flocculated matter was going on to the filters, the water immediately after washing would be clear and would continue to filter clear for perhaps 30 to 60 minutes. This indicated that it was coagulated properly. The filters would then start passing flocculated matter, which would keep increasing as the filter continued in service. The loss of head kept increasing at about a constant rate, and by the time it had reached 6 to 8 ft., which was from about 12 to 16 hours, the flocculated matter for some of the filters was in excess of 200. What happened was the flocculated matter which filtered out did not have time to compact before it was forced on further into the filter bed, or channels were formed through that which had filtered out.

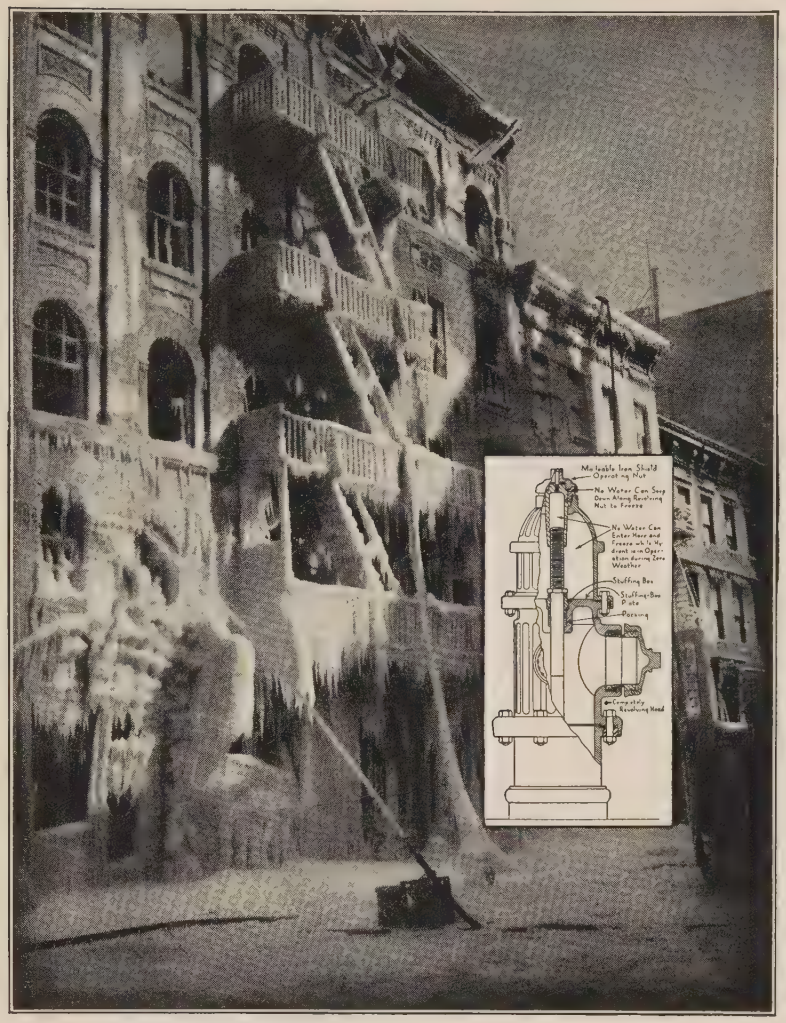
Compacting of the Flocculated Matter in the Sand Beds May Be Essential.—Time to allow the flocculated matter which has filtered out to compact itself at the surface and in the voids of the sand seems to be essential, otherwise in its loose condition it may be forced on deeper into the beds as the loss of head increases. The coagulation when first formed is largely water. Pressure exerted upon that which has filtered out in the sand beds tends to squeeze out some of the water. The writer has not made many tests to determine what percentage of the coagulated matter is water when the flocculation is first formed. It will be assumed to be 97 per cent, which is approximately the average of the several tests made. This is a ratio of about 1 of solid matter to 33 of water. If enough water is squeezed out so that it is only 90 per cent water, the ratio is 1 to 10. The flocculated matter would then occupy a space of slightly less than one-third its original volume. Large mud balls about 4 to 6 in. in diameter composed almost exclusively of aluminum hydroxide, and after deducting the weight of sand, were found to average about 92.7 per cent water. There is no proof that the compactness of the flucculated matter in a mud ball is the same as the compactness produced by filtration, but it is believed that quite an appreciable amount of the water is squeezed out of the flocculated matter as it is compacted in a filter bed. Not only is the volume of the flocculated matter materially reduced, but it becomes bound together more firmly. This compact flocculated is so tough there is not much danger of it being forced on through the filter beds, and it is not readily broken up into finer particles.

Fine Sand Will Filter the Flocculated Matter When It Is Weak.—The size of the voids through the sand, the depth of the sand bed, the strength of the flocculated matter, and perhaps certain other characteristics of the filter bed influence the penetration of the flocculated matter into the bed. A size sand may be used in which all flocculated matter will be filtered out regardless of the strength of the individual particles, but such sand is too fine for use in rapid sand filters. Also a sand may be used that is so coarse some of the flocculated matter will pass through the beds before the loss of head reaches 8 ft., even though the flocculation is tough. The coarsest sand that will filter satisfactorily the toughest flocculation likely to be produced may be somewhere near 3.0 mm. diameter, whereas the size required for the weakest flocculation may be only about 0.2 mm. With these extremes we have to make a compromise somewhere in the selection of the most suitable sand size sand. Due to the clogging difficulties encountered in many filter beds, the tendency is towards using a coarser sand, that is, sand from 0.4 to 0.6 mm. diameter for the 10 per cent size. The writer is of the opinion that this is a step in the right direction, for it aids materially in keeping the filter beds in good condition and gives longer filter runs. It makes it necessary, however, to exercise closer watch on the filtered water to avoid the passage of coagulated matter.

Objections to Flocculated Matter Passing the Filter Beds.—The main objection to coagulated matter passing the filter beds is that there is not perfect clarification of the water. The same amount of flocculated turbidity is more objectionable than the fine colloidal turbidity, for the flocculated turbidity is composed of masses so large they settle out to a certain extent in the clear water reservoir and in the mains. In fact there is a tendency for the finer masses to again flocculate into larger masses quite readily noticeable. This is the cause of the so called "after precipitation." If the water is not chlorinated prior to the addition of the coagulant, bacteria within the center of the suspended particles are not so easily killed by the chlorine. Very likely there are some instances in which the resid-

Even in Weather Like This

the Operating Thread of the



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ual chlorine disappears in the water before it has had time to penetrate through the coagulated particles. The diffusion rate of chlorine may be much greater than for some compounds, but it is not so rapid as some believe it to be, and when it has to diffuse through a gelatinous mass the rate is quite slow. The tests showing bacterial growths within the sediment in pipes as given in the October issue of WATER WORKS AND SEWERAGE clearly indicates that the diffusian rate of residual chlorine into gelatinous precipitates is extremely slow, for water with a constant residual of 0.2 ppm. did not diffuse through sediment 1/16 in. in thickness. Presumably the little organic matter in the sediment was enough to keep using up the residual chlorine as it diffused into the sediment, for bacteria increased to large numbers within the sediment. Now this same thing applies to coagulated particles, and their passage through filter beds may constitute a greater danger to the bacterial safety of the water than a fairly high colloidal turbidity, for the chlorine can get to the bacteria when they are not enclosed in the suspended particles. The writer has frequently remarked that a flocculated turbidity of 0.01 is more objectionable than a colloidal turbidity of 0.5.

Operators Frequently Guess at the Turbidity of the Filtered Water.—The inclination of many filter operators is to look at the filtered water in a bottle or beaker, and if it appears fairly clear to record the turbidity zero. Some are well aware that their water is not zero turbidity, yet they fear it will be a reflection upon the operation if the true turbidity is recorded. A few of the more conscientious will record the true turbidity if they have instruments for making accurate turbidity tests, but not many have such instruments. The writer has several times stated that the total turbidity of the filtered water should not be in excess of about 0.2 average for the day. This is clear enough for most any water where all the turbidity is colloidal, or such fine particles that they will not settle out, but it is entirely too high for flocculated turbidity. When the total turbidity does not exceed 0.2, the inclination is to assume the water is all right. In fact some who are making accurate turbidity tests assume that a turbidity of 0.5 is not objectionable, and do not try to reduce the turbidity so long as it does not exceed this figure. Water with so high a flocculated turbidity would be very objectionable.

No Such Thing As "After Precipitation."—When there is trouble from coagulated matter passing the beds the operators usually attribute it to "after precipitation," and believe there is nothing they can do to prevent the trouble. There is no such thing as "after precipitation" where the water is properly treated under favorable conditions for coagulation to take place. Very few filtration plants now have unfavorable conditions. The precipitate in the filtered water is merely flocculated matter which has passed the filter beds. Where there is a period of 15 to 20 minutes after the addition of the coagulant before the water reaches the filter beds it seems also impossible that any plant will have a precipitate formed after filtration. With no mixing of the chemicals with the water and the water thrown directly upon the filters, the flocculated particles may be so small and so imperfectly formed that some of the particles will pass through the beds and later flocculate into larger particles readily noticeable, but very few plants are operated under such conditions. The writer has heard operators in plants where there is fairly good mixing time and several hours settling state that they were having trouble from "after precipitation." Surely the water in such plants could not be so constituted that the coagulant remains inactive for several hours and then suddenly forms a precipitate.

How to Detect the Flocculated Turbidity.—It is essential for every well operated filtration plant to have some means of detecting the flocculated matter should any pass the filter beds. Not only should it be determined in the combined filtered water, but there should be some way of quickly determining if coagulated matter is passing any one of the filter beds. Such an instrument has been described by the writer in several articles[2], but somehow it has been difficult to convince those in charge of filtration plants that the detection of the flocculated matter is of any importance. It seems desirable to again illustrate the floc detector, especially as it would be difficult to describe how it works without an illustration. Sketch of an instrument suitable for mounting on filter operating tables is shown in Fig. 1.

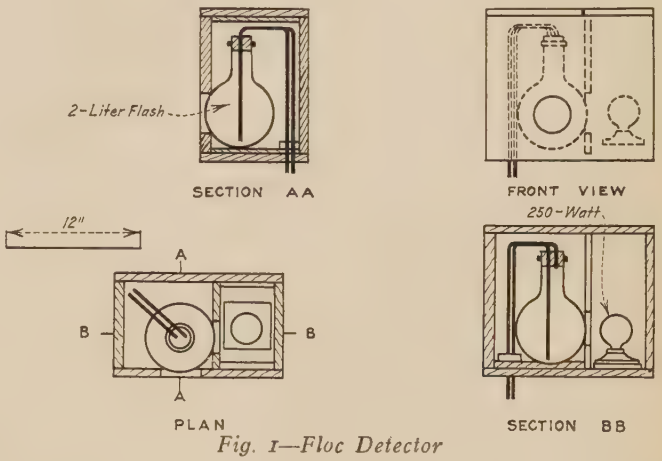

Fig. 1—Floc Detector

Perfectly clear water lets the light rays pass on through the water without any reflection, and suspended particles reflect the rays; that is, cause the particles to become illuminated. The light is at right angles to the sight, and is so located that it is not visible to the eyes. The instrument is not patented, and the writer has no interest whatever in the sale of such devices. After trying many devices for floc detection this was found to be the best for accurate results. So far as is known no one is manufacturing such an instrument at the present time and it may be necessary for each plant to have their own instruments made, but they are not difficult to construct.

An ordinary round bottom, short neck, laboratory flask may be used for holding the water. It is better to use the 2-liter size, though a smaller size might give fairly good results. The flash and light, which should be a very bright light, are enclosed in a box. There is a hole about 4 in. in diameter between the light and the flask, and a hole about 3½ to 4 in. in diameter for observing the water. All interior surfaces of both the compartment where the flask is located and the compartment where the light is located should be painted dull black. The flask being round has the advantage of magnifying the particles slightly. The magnification varies from none for particles at the surface of the glass nearest the observer to about 2 diameters for particles at the surface of the glass on the opposite side. Small copper tubes about 3/16 in. inside diameter are

[2]Sensitive detection of suspended matter. Public Works, 52: 6, Jan. 7, 1922.
Sensitive detection of suspended matter and a proposed standard of clarity for filtered water. J. Am. Water Works Assoc., 11: 824-32, July, 1924.
The Experimental Filtration Plant of Chicago, Ill. Municipal News and Water Works, 76: 89-95, March, 1929.
Significance and methods for determination of filter plant turbidities. Municipal News and Water Works, 76: 156-9, April, 1929.

suitable for leading the water into and out of the flask. The inlet tube should be connected to the filtered water effluent line from the filter, and the outlet tube should extend to a point several feet below the water level in the inlet tube if it is desired to operate by siphon action. The box should be of a neat design that will harmonize with the housing over the loss of head and rate of flow gauges. If only a few such instruments are needed it is cheapest to make the box of wood. Any company making such instruments for sale should make them with a metal cover.

The best place to locate the floc detectors usually is on the operating tables, though they may be located at any convenient point near the filter to which they are connected. When located on the operating floor the water has to be siphoned or pumped through the flask. Siphoning is the cheapest, and avoids the necessity for pumps, though there must be some convenient means of starting the water to siphoning. One essential feature of a device of this kind is to have it so it may be easily cleaned. During periods when the flocculated matter passes the filters before the loss of head reaches the maximum, and the floc detector is used to tell when a filter should be washed, the sediment accumulating in the flask is quite noticeable after being in operation for about a week. It is better to have the flask washed every week. With a rate of flow of about 100 to 200 cc. per minute part of the flocculated matter settles out in the flask, and the amount of sediment gives some indication of the performance of the filter.

At a later date the writer will give a procedure for measuring the volume of flocculated turbidity. Usually this is not done with the instruments attached to the filters, but in a similar device in the laboratory arranged to hold two flasks, one for the sample and the other for a standard of known flocculated turbidity.

Plant Results Show the Need of Floc Detectors on Every Filter.—Table I gives the results of tests on a filter which was typical of all the filter beds in the plant. The sand bed was in excellent condition, and the 10 per cent size of the sand was about 0.45 mm. diameter. The water temperatures was about 1° C., and the rate of filtration was approximately 2 gal. per square foot per minute. The water was well coagulated as is evident from the fact that the turbidity of the filtered water just before the flocculated matter started to pass was 0.0.

This filter, as well as all the other filters in the plant, was giving perfect results only a month previous to the test when the water temperature was about 5° C. After the water temperature increased slightly in the spring all the filters again would go to 8 ft. loss of head without passing flocculated matter. There was so much flocculated matter passing the filters in this instance that the operator may have discovered that something was wrong without a floc detector, but a lesser amount of flocculated matter might not have been detected by the usual tests. It takes about 3.0 volumes of coagulated matter to produce a turbidity of 0.2 in the filtered water when all the turbidity is due to flocculated matter. Turbidity of 0.2 would not cause any one to suspicion the water was not all right, yet this amount of flocculated matter is very objectionable. With a floc detector the operator should have washed the filters after 5 to 6 hours service, and without one he likely would have allowed the filters to run 24 to 36 hours. Certainly the performance of these particular filters after 12 to 16 hours was very unsatisfactory.

There was not a thing in the plant performance to indicate that flocculated matter was passing the filter beds. There had been no material change in the water so far as could be observed. The rate of filtration was in accordance with customary practice, all the beds had previously been giving good results, the loss of head increased about as usual except it may have gone up at a slower rate, the quantity of coagulant was about what was generally used, and the water appeared to be well coagulated. In other words, there was every reason for the operator to believe the filters were functioning all right, and had the water not been tested with the floc detector the occurrence of flocculated matter in the filtered water might not have been detected until large amounts were passing.

All operators who do not use some means of detecting the flocculated matter in their filtered water are not availing themselves of every safeguard essential for good filter operation.

Table I—Measurements of Flocculated Matter Passing a Filter Bed

Hours in Service	Loss of Head in Feet	Turbidity of Filtered Water	Volume of Flocculated Matter in Filtered Water per Million Volumes of Water
0	.8	.0	.0
7	1.5	.1	1.0
24	3.1	.2	3.0
30	3.9	.3	5.0
49	6.0	.5	10.0
54	6.7	.7	12.0
73	8.6	1.0	15.0
79	9.3	2.2	25.0

State and Municipal Bond Election Results During November

New state and municipal bond authorizations reported by 195 communities during the month of November totaled $413,976,450, the largest November total for any year to date, according to The Daily Bond Buyer of New York. November totals for previous years were $48,499,834 in 1929, $345,933,415 in 1928, $127,623,950 in 1927, and $198,098,410 in 1926. The huge figure last month is largely accounted for by the following substantial authorizations: New Jersey, $100,000,000; New York, $50,000,000; California, $20,000,000; Louisiana, $80,000,000; North Carolina, $10,000,000; Montana, $3,000,000; Chicago, $20,670,000; Cleveland, $31,500,000; San Francisco, $10,850,000; New Orleans, $4,500,000; and Golden Gate Bridge & Highway Dist., Cal., $35,000,000.

Total municipal bond authorizations for the first eleven months of this year amount to $632,454,950 as compared with $403,993,334 during the corresponding period last year, $760,167,606 in 1928, $492,187,989 in 1927 and $602,582,722 in 1926.

The following table, compiled by The Daily Bond Buyer, presents a comparison of bonds approved by months for the past three years:

	1930	1929 (.000 omitted)	1928
January	$ 11,620	$ 26,950	$ 14,140
February	17,861	13,309	8,204
March	33,741	22,154	21,636
April	45,325	37,963	77,465
May	56,823	61,852	136,989
June	13,414	53,711	45,609
July	14,628	35,895	59,211
August	3,369	16,540	22,010
September	8,590	85,308	16,870
October	4,136	21,760	12,096
November	413,976	48,499	345,933
December	.....	17,002	23,244
Total	$632,454	$420,995	$783,412

A Rain Cycle Caused by the Moon

By HALBERT P. GILLETTE

MOST farmers still believe that the moon affects the weather in spite of the certainty with which meteorologists assure them that it does not. I have recently found that the moon does cause rainfall, although the cycle that it produces is not the same length as the cycle of the moon's phases. The cycle from full moon to full moon is 29.53 days. This is the lunar month, or what astronomers call the synodic period of revolution of the moon; but the true period of its revolution is 27.32166 days, which is its siderial period. This true period of revolution seems never to have been investigated by meteorologists, so I decided to investigate it. For this purpose I took the daily rainfall records at Juneau, Alaska, starting Jan. 1, 1917. I choose an Alaska station because of the frequency of rainfall and the infrequency of great departures from the daily average, and because of nearness to the Aleutian low. By tabulating the rainfall data in 27 columns, I built up what may be called a cyclogram, and the totals of each of the 27 columns soon disclosed a tendency toward greater rainfall about every 7 days. So I then took one-quarter of the 27.32166 period of revolution, which is 6.8304 days and built a cyclogram having 7 columns, inserting in the first column and first line the rainfall at Juneau on Jan. 1, 1917. Then in the first column and second line was entered the rainfall on Jan. 8; and in the first column third line, the rainfall on Jan. 15. But since the assumed rain cycle was not quite 7 days, it was necessary to drop a day every once in a while in order to "keep in step" with the assumed cycle of 6.8304 days. Thus 3×6.83 is 20.49 days, which is nearer 20 than 21 days; hence the rainfall on the 20th day after Jan. 1, or Jan. 21, was entered in the fourth line of the first column, instead of the rainfall on Jan. 22. In this way the cyclogram was built up until it included 480 cycles covering the daily rainfall for 9 years; and it was found that the total of the rain on days listed in the first column exceeded the total on days listed in the fourth column by nearly 40 per cent. Applying the law of probability to the results thus secured, I found that the odds are more than 1,000 to 1 that this is not an accidental result. It follows, that it is highly probable that the moon causes a rainfall cycle whose length is 6.8034 days.

It is has been so frequently observed that rains tend to occur a week apart that there is an adage to the effect that "If it rains on the first Sunday of a month it will probably rain on every other Sunday of that month." The adage wold hold equally true if Monday or any other week day were substituted for Sunday; but since Sunday is a day of rest, people are more apt to be observant of rainfall than when occupied with the routine of their week day tasks.

Clayton, in his book on "World Weather," says that there is unquestionably a tendency for rainy days at times to occur about a week apart in certain regions; but he attributes this cycle to an alleged sunspot cycle of about a week. He points out that the sun rotates in 27.28 days in the region where sunspots are most numerous, and he takes one-quarter of 27.28 days to get a rain cycle of a little less than a week. But I have made cyclograms of sunspots, like the one above described for rainfall, and I have found no evidence of a sunspot cycle of about a week. However, I did find a sunspot cycle of 29.55 days with subcycles of one-sixth thereof, or slightly less than 5 days; and I also found a rainfall cycle at Juneau of that length. Hence I surmise that this sunspot cycle with its accompanying rain cycle is one that led farmers to regard the moon's phase cycle of 29.53 days as being associated with rainfall. It will be observed that there is a difference of only 0.02 or one-fiftieth of a day between the sunspot and rain cycle of 29.55 days and the lunar month of 29.53 days; hence those cycles would remain nearly "in step" for many months.

To a certain extent the farmers seem to have been better observers than the weather experts, for they have certainly had a basis of fact to support their belief in a rain cycle of about the length of a lunar month.

I confess to having been greatly surprised in finding a rain cycle so nearly equal to the length of the lunar month. I was even more surprised at finding one exactly equal to the true period of revolution of the moon, and one quarter thereof. Of course, cycles, due to magnetic forces, often interfere with one another; and since there are fully 30 rain cycles, no cycle will always show rainfall maxima regularly. Moreover it frequently happens that the interference is prolonged to such an extent that the cycle under investigation seems to have been, purely ephemeral, but about the time that the investigator begins to regard it as ephemeral the cycle again makes its appearance with its peaks and valleys where they should be. The lunar rain cycle of 6.83 days has been almost obliterated during the last 4 years, and were it not for its pronounced and prolonged existence during the preceding 9 years, question would arise as to its real existence.

Turning again to the solar cycle of 29.55 days and one-sixth thereof, evidence of its existence is to be seen in a temperature curve given in a paper by Roscoe Nunn in the Monthly Weather Review, January, 1927, entitled, "The January Thaw." Mr. Nunn shows four smoothed curves of daily temperatures during January, taking the averages of 46 Januaries in New York, Philadelphia, Pittsburgh and Baltimore. The curves all agree in showing a very striking peak about Jan. 21, and they also agree in showing five other lesser peaks at intervals of about 5 days. These temperature intervals are in such close agreement with the sunspot and rain cycle of $1/6\times29.55$ as to make it quite certain that they are the effect of that cycle. Although the 29.55 day cycle is not harmonic with the length of the year, these January temperature cycles may be explained thus: On Jan. 21 the earth's longitudinal position relative to the sun is such as to cause exceptional activity in the six electron whirls that presumably exist permanently in the sun. Then the reactive magnetic effect of these six electron whirls on the earth's permanent electron whirls results in an exceptional number of cyclonic storms. These rotating storms bring warm southern air northward and thus cause the January thaw.

Mr. Nunn states that the direct cause of the January thaw is due to cyclonic storms "inducing southerly winds in the eastern states," but he adds that "No explanation of the (fundamental) cause of the (January thaw) abnormality has ever been offered, so far as the writer knows." He quotes Prof. Marvin to

the effect that "The human mind knows no reason why there should be an irregularity of this character; we are compelled to think of the normal temperature as a smooth progressive curve." This alleged compulsion exists only in a mind that is strongly under the influence of the theory that solar radiation entirely explains all periodic meteorological phenomena. The fact is that it does not, and as soon as the mind frees itself from such a belief, the "January thaw" and scores of other "anomalies" take on great significance. They point, without exception so far as I know, toward electron activity as a very important factor in weather.

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Exposed Water Mains and Air Valves in Cold Climates

The following remarks, applying to water mains on bridges and to air-relief valves in cold climates, were contributed to a round-table discussion at the St. Louis convention of the American Water Works Association by G. G. Routledge, superintendent, Water Distribution section, Toronto, Ont.

Support of Pipes.—The size of the main should be ample for present and estimated future requirements.

As the pipes are likely to be subject to vibration and stresses considerably greater than they would be underground, special attention should be given to materials and to their protection from rust and tuberculation.

The openings in the bridge abutments for the pipes should be large enough to permit the pipes to be passed through them and leave sufficient space for insulation. Scaffolding usually secured to bridge members will, in most cases, be necessary for the construction of the pipe line, and where possible should be permanent for pipe inspection and repairs. In some cases the most convenient method of getting the pipes into position is to pass them through the openings in the abutments and then move them on rollers on the scaffold. In others it will be more convenient to hoist them on to the scaffold from some point below the bridge.

Bridges on which pipes have to be placed vary so much in design that the best method of supporting the pipes also varies considerably. In some cases, brackets supporting the sidewalks provide convenient support for the pipes; in others, the pipes can be suspended with iron rods from the floorbeams or attached to other bridge members. It is advisable to have two supports to each pipe so that in the event of a failure at a joint the pipe itself will be securely held in position.

Pipe Joints.—Until a few years ago only two kinds of joint for pipes on bridges had been used, the ordinary screw coupling and flanged-and-bolted connections. The screw-coupling joints have been found a little more difficult to make watertight, but when once tight remain so. They also have an advantage over flanged joints in that they offer no difficulty to the installation of insulating materials. Flanged joints permit of a pipe being taken out of the line more easily, but in these days a repair would usually be made by welding rather than removing the pipe.

As both of these joints are practically rigid, it is advisable to install special joints to take care of expansion and contraction in the pipe. The ordinary stuffing-box type of expansion joint has been satisfactory. The range of change in temperature of Lake Ontario water is about 40 deg., which would mean a variation in length of a 20-ft. length of pipe of 1/16 in.

The material of which the bridge is constructed will generally be subjected to a range of temperature two or three times that of the pipe; this will result in movement at the points where the pipe is attached and will possibly disturb the insulation at these points. This has been avoided during the last few years by using Victaulic couplings, thus making each joint an expansion joint. They permit a movement, without leakage, considerably greater than that resulting from changes in temperature.

Air Valves.—In most cases the construction of a pipe line on a bridge results in a high spot where air may accumulate. Automatic air valves and ordinary 1-in. connections with gate valves have been used for the removal of air at the high points, and these have given more trouble, especially the former, than any joint or other fitting on the bridge. The high spot is usually at the center of the span, and in a position difficult of access for inspection and repairs. In some cases a manhole in the floor of the bridge can be constructed to provide access, but in most cases it will have to be reached from below with ladders or scaffolding.

In order to find the velocity necessary to remove air from the high point in an 8-in. pipe, an experiment was made with a 5½-ft. length of 8-in. pipe laid horizontally, and connected with elbows to the tops of a vertical 8-in. inlet pipe and a vertical 6-in. outlet pipe. The inlet and outlet pipes were about 8 ft. long. A valve was placed at the lower end of the outlet pipe to control the flow.

The static pressure on the supply mains was about 75 lb. An air compressor was used to displace the water in the horizontal pipe and in about half of the 8-in. vertical inlet pipe. Several tests were made and each one indicated that an average velocity in the 8-in. supply pipe of about 2 f.p.s. removed all air from the pipes.

Except where easily protected and made readily accessible for operation, any advantages there may be in having an automatic air valve on a bridge are more than offset by the difficulties in protecting and maintaining it in working order.

Almost every winter we have had trouble with air valves on bridges which were left in service. Instead of attempting to repair them, they have been removed and so far there has been no evidence of ill effects resulting from their removal. On all our bridges there is a daily demand insuring a velocity in the pipe sufficent to remove all air. On an ordinary distribution system the accumulation of air at a high point will not interfere with the flow to an appreciable extent. Where very low heads only are available, an air valve at a high point is, of course, necessary, but my present opinion is that there are no serious consequences to be anticipated from the ordinary distribution main being installed over a bridge with a high point without having at that point an air valve.

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Sewage Disposal Plant as Public Utility

The Ulen Co., of New York, a well known firm of contractors, has submitted a proposition to the city of Monroe, Mich., to build and operate a sewage disposal plant for that city. The company offered to build a plant, construct a $1,000,000 system of lateral sewers to connect with the present city system and build a pumping station to deliver the sewage to the plant. The entire investment would be made by the company with no capital outlay by the city and a charge would be made to the residents on the basis of their water consumption.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by A. ELLIOTT KIMBERLY
Consulting Sanitary Engineer, Columbus, O.

Glass Covered Sludge Beds

Continuously effective sludge disposal and improved methods of preliminary treatment are particularly stressed in present day American sewage treatment practice. Modern plant design aims to secure odorless operation, requires highly trained and skillful operators, complete laboratory control at the larger plants and partial control at the small installations. Sewage treatment is a public utility and on this basis, emphasis is properly placed upon attractiveness and freedom from odor. The hidden and forgotten sewage treatment plant of earlier days has gone. Today by pleasing landscaping and through intelligent operation, with the aid of devices and processes which make possible practically odorless operation, including chlorination, the public is beginning to take as much pride in its sewage treatment plant as it has done in its water purification plant, a fact which stimulates efforts to maintain high class operation and maximum efficiency in sewage treatment. Many of the recent large plants are moreover, virtually public parks, visited by many and in some instances adjoined by a public golf course.

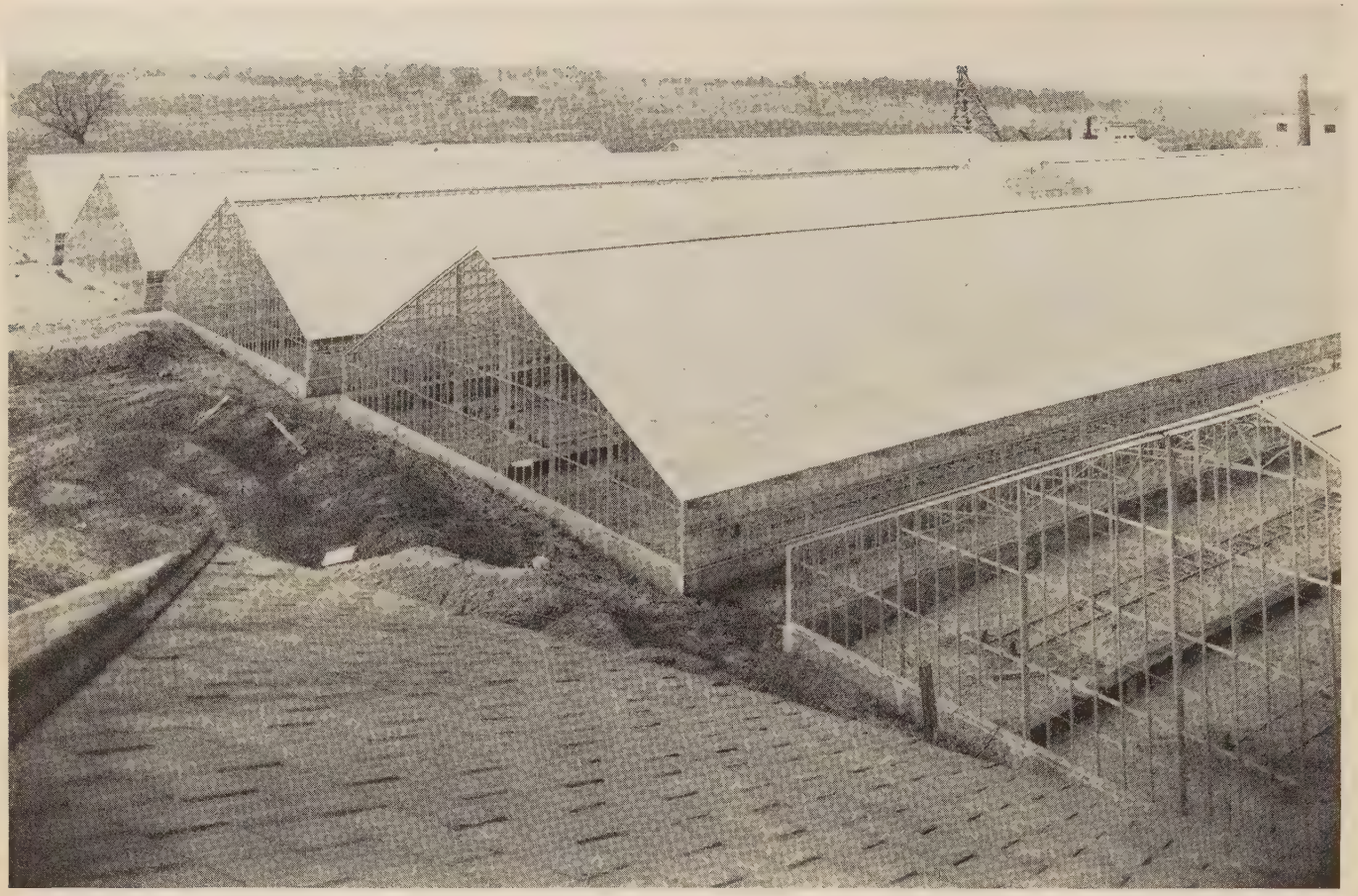
Sludge Disposal a Frequent Source of Odors.—Obviously, one of the most difficult problems in sewage treatment is the disposal of sludge, a question which has confronted the engineering profession since the early days of chemical precipitation. Even under efficient preliminary treatment, there is a definite relation between odors at sewage treatment plants and methods of handling and disposing of sludge. More or less odor is, of course, to be expected, until the sludge has at least superficially oxidized and has dried out to a spadeable condition.

Experience at many plants have demonstrated conclusively that odorless operation must in particular not only include adequate areas for sludge drying, but also some means for year round drying, so that tank operation with respect to the withdrawal of sludge therefrom, can function irrespective of weather conditions.

Sludge Drying Under Glass.—To make possible continuous year 'round sludge drying, a large number of recently constructed plants, particularly those built since 1928, provide glass covered sludge beds. Probably the largest installation to date is at Dayton, O., where 105,000 sq. ft. of glass covered sludge beds are in use, designed for a population of 262,000, on the basis of 0.4 sq. ft. per capita. Dayton has 11 units, inside dimensions 59 ft. 10 in. x 162 ft. 6 in.

The housing of sludge beds under glass, an idea apparently originated at the Cleveland Sewage Testing Station in 1913, appears to have been first used in 1915 at a small institutional sewage plant near Pleasantville, N. Y., designed by Andrew J. Provost of Lederle &

Installation for Sewage Disposal Works of Dunkirk, N. Y.; Moore Construction Co., Buffalo, N. Y., Contractor; Glass Enclosure by American-Moninger Greenhouse Mfg. Corp.



Glass Covered Sludge Beds at Dayton, O.; Metcalf & Eddy, Boston, Mass., Engineers; Glass Enclosures by Lord & Burnham

Provost of New York, where plain sedimentation comprised the preliminary treatment. This pioneer installation used the low form, sloping glazed sash common to the well known florist's hot bed construction. It is of interest to mention that the covering of the sludge beds at this small plant was for the purpose of preventing the escape of odors developing during the discharge of fresh sludge.

Advantages.—From a review of sewage treatment literature and from discussions at sewage treatment plant operator's conferences, throughout the country, it is noticeable how frequently emphasis is placed upon sludge drying difficulties, which develop in practical plant operation, even though in many instances, standard per capita open sludge bed areas have been been provided by the designer. It is obvious that the rate of drying and the practical area required per capita for sludge drying beds, are functions of weather conditions. Consequently, the net yield of dried sludge per square foot of sludge bed area is most decidedly reduced for open beds, during periods of wet weather. It therefore follows that the area provided for open bed sludge drying must include, as it does, a substantial factor of safety against adverse weather conditions.

Not only does rain retard sludge drying and prevent the further discharge of wet sludge on to a bed until the older deposit has thoroughly dried, but it also has the effect of beating out the gasses, making the sludge less porous and decreasing its drainability.

It is apparent also, that in the northern part of the United States and in Canada, sludge drying on open beds is impossible during the winter months and the use of covered beds is common practice. To provide for winter conditions, plants without covered sludge beds must have sufficient sludge storage capacity in separate sludge digestion tanks or in Imhoff tanks or else resort to lagooning, which with the return of warmer weather, may give rise to objectionable odors.

It is the experience of plant operators, where glass covered sludge beds have been provided, that not only is the odor incident to sludge drying eliminated, but also that far greater flexibility is possible in preliminary treatment operation.

Still another reason for the increasing use of glass covered sludge beds, is the fact that the appearance of the plant as a whole is materially improved by these attractive glass housings, which readily blend into the general plan of landscaping and beautification of the modern sewage treatment plant.

It is finally of interest to suggest the importance of a clean sludge drying bed for the operator forced through some unexpected development, immediately to withdraw sludge from tanks or sludge digestors, a situation which with open sludge beds can frequently not be met because of adverse weather conditions.

At many plants, a sale for dried sludge has developed in the community and where continuous sludge disposal is made possible by glass covered sludge beds, uninterrupted accumulation and preparation for the market may proceed at a definite rate, even throughout the winter season.

The advantage of glass covered sludge beds may be summarized as follows:

1. Continuous drying and orderly plant operation, irrespective of weather conditions.
2. Uninterrupted sludge drying during extreme winter weather.
3. Control of odors from freshly discharged sludge or from partially dried sludge.

4. Adaptability to landscaping programs, compactness and neatness.
5. Reduced sludge drying area requirements.
6. Possibility of accelerated drying through controlled ventilation or the use of hot air.
7. Prevention of mosquito breeding in pooled sludge.
8. Ability to utilize sewage treatment plant sites less remote from residential districts.

Sludge Bed Areas.—Current practice with respect to required sludge bed areas, depends upon the condition of the sludge, which in turn is dependent upon the type of preliminary treatment which has produced it. Generally speaking, glass covers over sludge beds permit area reductions of from one-third to one-half, as compared with open beds, depending upon conditions and varying somewhat in different parts of the country.

It is not surprising that opinions differ as to the reduced area possible with covered beds, because of the many variables with respect to the actual physical condition of sludge as drawn, even when produced from a similar type of process. Sewages, of course, vary greatly in composition and likewise, sludge.

In many instances plants with covered sludge beds are not operated up to designed capacity and therefore sludge drying data are not comparable with results that may be obtained as the population load more nearly approaches the basis of design.

Although the extended use of glass covered sludge beds is too recent to permit the accumulation of many actual operating data covering a more or less complete range of conditions as regards character of sewage sludge, temperature and weather, yet it is believed that the operating data at present available, justify tentative standardization at least as to practical loadings of well digested sludge in terms of cubic yards per square foot of glass covered beds per year.

State Health Departments have adopted requirements for open and covered sludge bed areas, of which that of New York is typical. As indicated in the tabulations below, the required areas are differentiated with respect to the origin of the sludge. Pennsylvania requirements for well digested sludge are 0.4 sq. ft. per capita, the same as provided at Dayton, O.

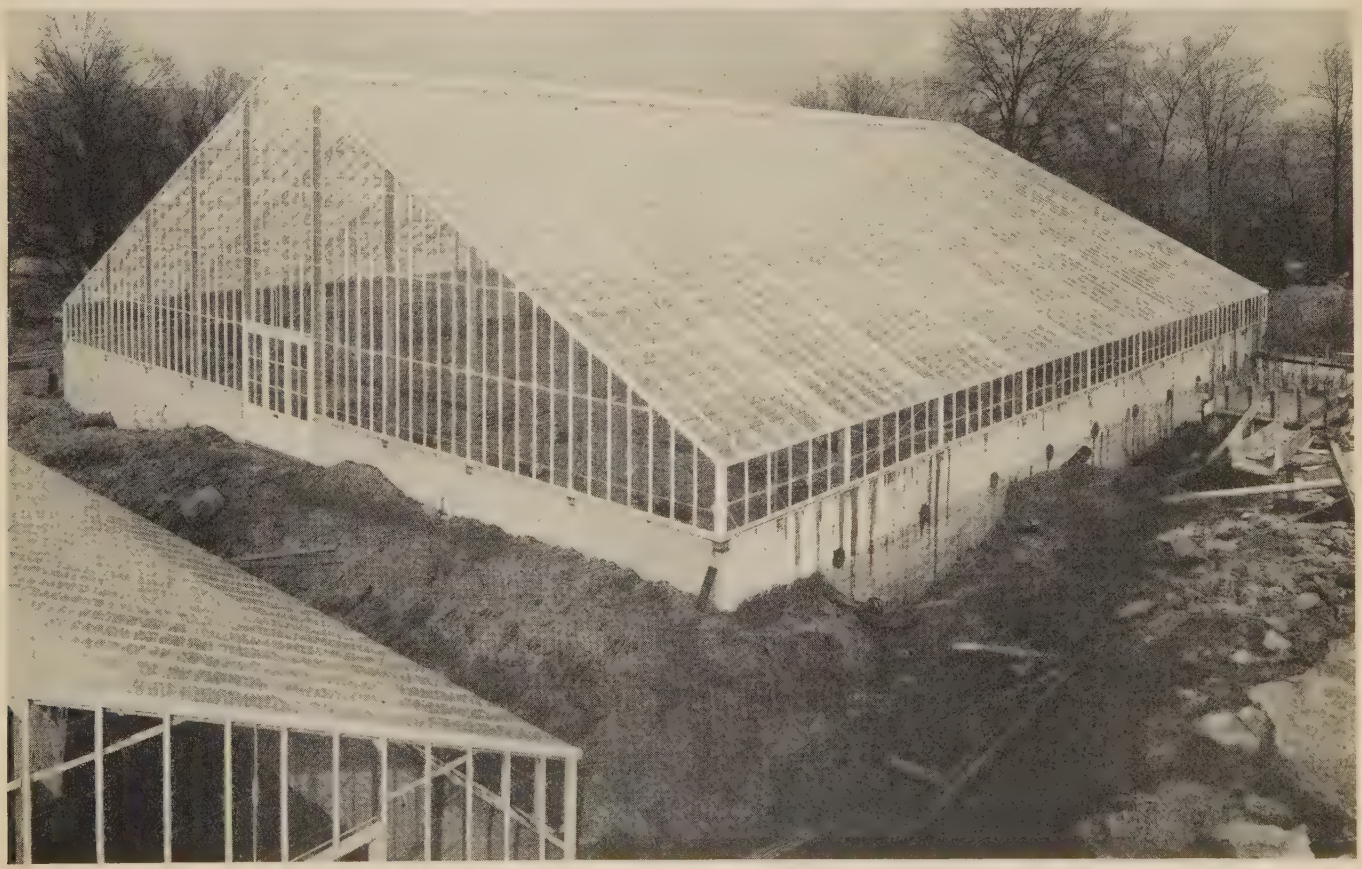
Sludge Bed Area Requirements of New York Department of Health

Preliminary Treatment	Sq. Ft. Open	Per Capita Glass Inc.
Plain settling, less than 5 hrs.	5.0	2.5
Plain settling, greater than 8 hrs.	3.0	1.5
Two-story tanks	1.0	0.5
Separate digestion tanks*	1.5	0.75
Secondary or final settling tanks	0.5	0.25

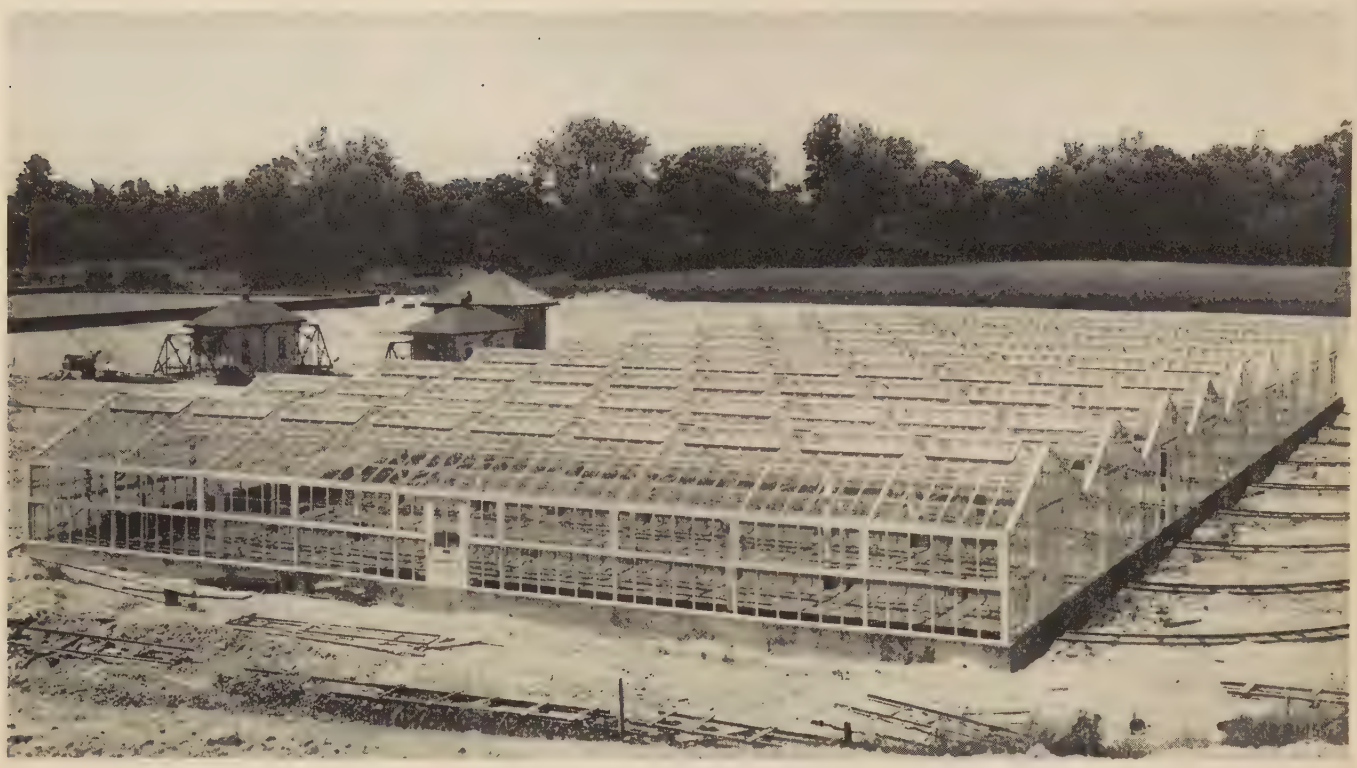
*Also digested activated sludge.

Interpretation of Experiences at Marion, O.—Until operating data are available from the many covered sludge beds constructed within the past three years, judgment as to covered sludge beds loadings may be helpfully guided by an interpretation of their performance at one of the early installation, where glass covered sludge beds are used, namely at Marion, O., a plant which began operation in July, 1924.

A paper by Floyd G. Browne, superintendent, and Frank Woodbury Jones, sanitary chemist, with George B. Gascoigne, Cleveland, O., read last spring before the New Jersey Sewage Works Association, describes the very interesting and instructive sludge drying tests made at Marion, O., throughout the year 1929. In these tests, two sludge beds, receiving well digested Imhoff tank sludge were operated to capacity. It was the author's recent privilege to discuss this paper with Mr. Browne who kindly also made available many other instructive and pertinent data on underglass sludge drying.



Sprinkling Filter Cover at West Patterson, N. J.; H. J. Harder, Patterson, N. J., Engineer; Glass Enclosure by Hitchings & Co.



Covered Sludge Beds at Alliance, O.; George B. Gascoigne, Cleveland, O., Engineer; Glass Enclosures by King Construction Co.

Marion is sewered on the separate system and the treatment plant is of the Imhoff tank-trickling filter type. During 1929 the suspended solids in the raw sewage averaged 227 p.p.m. with a maximum of 470 parts and a minimum of 109 parts. The average removal of suspended solids by the Imhoff tanks was 60 per cent.

From Jan. 1, until Dec. 31, sludge was applied to two of the glass covered beds. The minimum depth of application was 7.2 in., the maximum, 10.8 and the average about 9.3 in. The average depth of the dried sludge was 3.6 in. with an indicated volume shrinkage of approximately 60 per cent. The drying period averaged nearly 16 days, with a minimum of 6 days and a maximum of 43 days. The sludge as applied averaged 7.1 per cent solids. The dried sludge as removed averaged 32.5 per cent solids.

It was possible to secure for each bed, for the calendar year 1929, 20 dryings or a total disposal of 0.58 cu. yd. of wet sludge per square foot of drying area. During 1929, 624 million gal. of sewage were treated at Marion, producing 3,827 cu. yd. of sludge containing

Installation at Rockland State Hospital, Orangeburg, N. Y.; Glass Enclosure by King Construction Co.

7.1 per cent solids, from an estimated tributary population of 25,000 or 4.1 cu. ft. of wet sludge per person per year. On the basis of the application of 0.58 cu. yd. or 15.7 cu. ft. of 7.1 per cent solids sludge per square foot, 1929 experiences at Marion, indicate the possibility of underglass drying, at the rate of $\frac{15.7}{4.1}$ or about 0.38 sq. ft. per capita.

In the discussion of these tests, it is pointed out, that if a sludge of 8.0 per cent solids is applied to covered beds or if the depth of application is slightly increased, it appears that as a maximum loading for digested sludge, the required area may be 0.33 sq. ft. per capita. It should furthermore be mentioned that at Marion, during the year 1929, the rainfall was about 15.4 in. in excess of normal, with a total precipitation of 54.03 in. and only 122 days of the 340 days sludge was on the beds or only about 35.6 per cent, were clear or partly clear. The inference is that under normal weather conditions, drying conditions would have been much better than was the case during these tests. The data are most timely and instructive, indicating that present accepted population covered sludge bed area requirements may be expected to be sufficient, under practical operating conditions. It is of interest to consider what great difficulties would have confronted the Marion plant during 1929, were open beds provided with accepted population-area loadings.

Sludge Volumes.—The volume of sludge is, of course, a function of the per cent of dry solid matters and sludge bed area requirements must, of course, vary accordingly. The importance of having available, for ready reference, without calculation, data showing the relation of dry solids and sludge volumes is doubtless of much interest in plant operation. A valuable table showing these relations, appears in a paper by F. E. Daniels, chemical engineer, Pennsylvania State Department of Health, presented at the first conference of Sewage Works Operators, at the Pennsylvania State College, State College, Pa., in July, 1926. These data, computed to per cent dry solids, are given in the next table. The well known tremendous reduction in sludge volume as the per cent of solids increases, especially during the important range from 0.1 to 10.0 per cent, is strikingly evident.

Dry Solids and Volume Relations in Sewage Sludge*

Per Cent Solids	Vol. Sludge	Per Cent Solids	Vol. Sludge
100	1.00	15	6.66
99	1.01	10	10.00
98	1.02	5	20.00
95	1.05	4	25.00
90	1.11	3	33.33
80	1.25	2.5	40.00
70	1.43	2	50.00
60	1.66	1	100.00
50	2.00	0.9	111.00
40	2.50	0.6	166.00
30	3.33	0.5	200.00
25	4.00	0.1	1000.00
20	5.00		

*Pennsylvania State College, School of Engineering, Tech. Bull. No. 1.

Economic Aspects.—Assuming 0.4 sq. ft. per capita, as a tentative standard for covered sludge beds receiving well digested sludge, it is evident that by providing underglass sludge drying, the required areas are reduced 60 per cent. Furthermore, site area is conserved on account of the compactness of glass housed beds.

The cost of standard greenhouse construction for sludge beds averages about $1.60 per sq. ft. The average total cost of covered sludge beds, including track-

Interior of Installation for City of Dunkirk, N. Y.; Glass Enclosure by American-Moninger Greenhouse Mfg. Co.

age, is about $2.75 per square foot, with a range from $2.50 to $3.00.

With the above average cost for glass covered beds, it is evident that not only is it not more expensive to provide for sludge drying under glass, but actually glass housed sludge beds are cheapter. The greater convenience of continuous sludge drying regardless of outside weather conditions and the many other advantages inherent in their use, explain why glass covered sludge beds are being accepted as standard practice, in all parts of the country. The extent to which glass covered beds are being used, is clear, when it is recalled that while there were only about 10 glass inclosed sludge beds in 1926, at the present time in excess of 100 installations are either in actual operation or are included in the layout of plants, at present under construction.

Experience at Marion, O., during the past 6 years, indicates what is to be expected with respect to the maintenance of glass covered sludge beds, the extent of glass breakage and the liability of serious damage during wind storms and from hail.

During the first 4 years operation at Marion, maintenance costs include $1,700.00 for labor and material for painting, or a total cost of only about 3.4 ct. per square foot of sludge bed area per annum. A very few panes of glass were broken by accident and none by the wind or by hail.

In connection with painting, it has been found at Marion that an aluminum paint with an asphaltic or gilsonite base, using a chrome primer, is excellent for painting the frames of glass covered sludge beds and general use at sewage treatment plants. The color is not appreciably affected by hydrogen sulphide. Provided good coverage is obtained, one coat is sufficient.

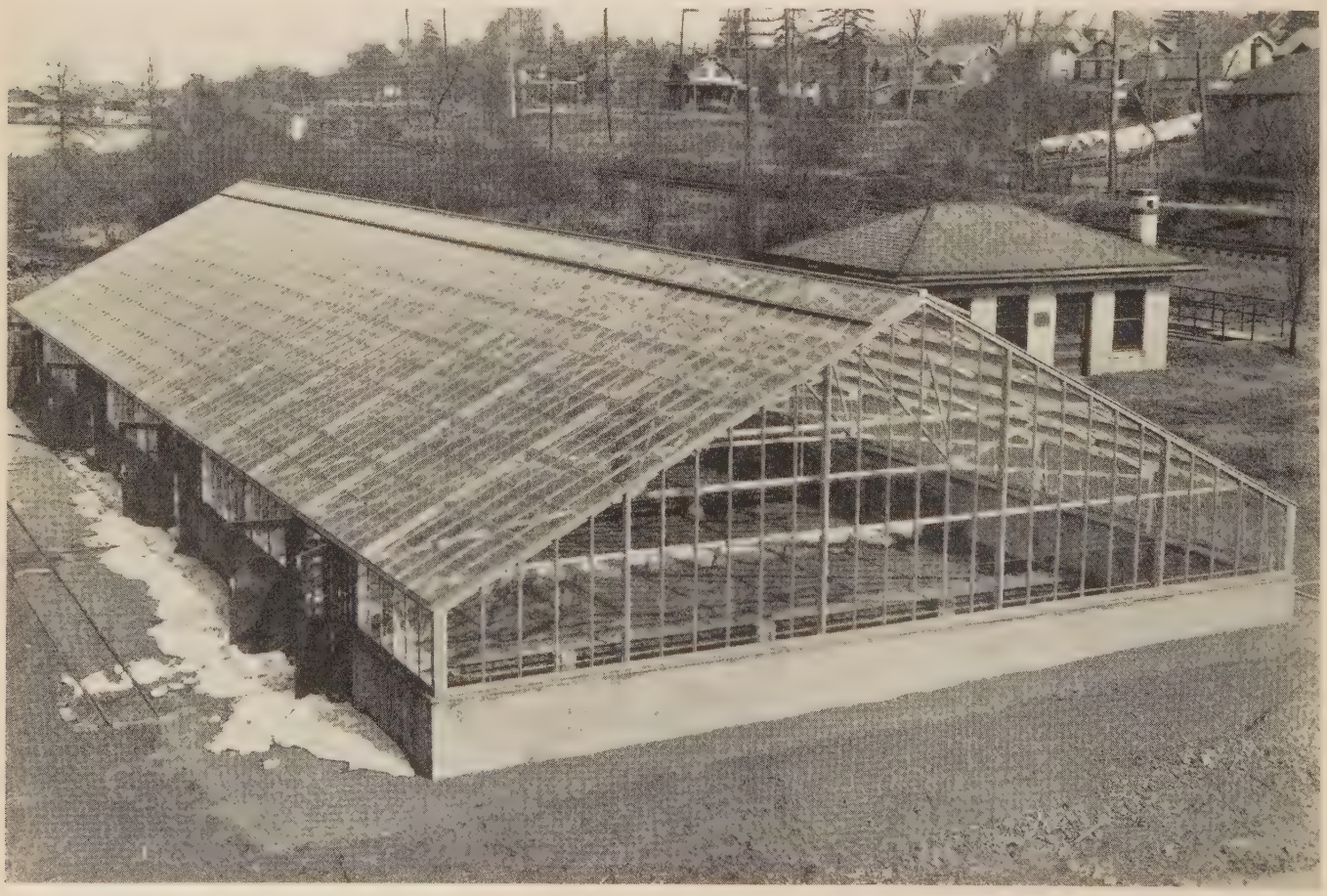
Sand replacement at Marion was 45 tons per bed in 4 years or a total of 450 tons. This operation, moreover, increased the original depth of sand several inches. It is evident that the maintenance cost per annum for replacing sand losses is quite nominal and that the same charges are obviously applicable to open drying beds.

Hail and tornado insurance are desirable at sewage treatment plants with glass covered sludge beds. The rate, of course, varies in different sections of the country, according to hail and tornado experiences and it is therefore not feasible to quote specific rates of definite applicability. However, generally speaking, the rate is not excessive and a majority of plants with glass covered sludge beds carry tornado and hail insurance on the glass.

Conclusion.—Glass covered sludge beds are quite generally accepted as important and essential features of the modern sewage treatment plant producing digested sludge and are also in use in a few relatively small plants handling excess activated sludge. In Canada, because of climatic conditions and at several places in this country, with a view to beautification and odor control, relatively small plants have been completely inclosed in glass. A field for glass covered sludge beds and sewage treatment plants entirely glass inclosed, appears to be at estates and at country clubs, where odors must be prevented and esthetic features of design stressed.

In view of marked area reduction, the cost of covered beds is frequently less than that for open beds. Maintenance costs are low and glass breakage negligible. Wholesale destruction by hail can be inexpensively covered by insurance.

Operating data are needed as a guide to future design. It is believed that the results from the operation of the many plants planned and built during the past 2 or 3 years, will shortly result in greatly increased knowledge



Installation at Bogota, N. J.; Andrew J. Provost, New York, N. Y., Engineer; Glass Enclosure by Lord & Burnham

of the rationale of sludge draining and drying under glass.

Some important studies have already been made respecting ventilation, the application of heat and other features relating not only to cover design and general layout, but also to improved details of the sand or drainage beds themselves. The interpretation of the large mass of practical information which will apparently be available within the next few years, will doubtless increase still further the use of the glass covered sludge bed, a device which has so many distinct advantages over the unreliable, open, weatherbeaten bed, which it is so effectively replacing.

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Frost Protection for Exposed Mains

Frost protection for exposed water mains is a subject of great importance in the colder regions of North America. The following interesting discussion of the problem was presented by R. L. Dobbin, general manager, Peterborough Utilities Commission, Peterborough, Ont., in the superintendents' round table discussion (Journal Am. W. W. Assn., October) at the St. Louis convention of the American Water Works Association.

A search through the Journal of the Association from 1908 reveals no papers or discussion on the subject until 1928 when Mr. George Routledge, superintendent of distribution of the Toronto Water Works Department, read a paper before the Canadian Section on "Constructing Water Mains on Bridges," which described various methods of protecting such mains. This paper was published in the August, 1928, number of the Journal.

One method described by Mr. Routledge consisted of constructing a wooden box around the main, and filling the space between the main and the box with dry sawdust to a minimum thickness of 3 in.

A second method was to cover the main with layers of insulating felt to a thickness of 2 in., and then cover the whole with a jacket of metal or heavy asphalt roofing secured with galvanized iron or copper wire.

Other methods consist of using a very thick layer of gypsum around the main.

All of these methods are very satisfactory, but our experience has been that there must be circulation of water in the main to keep it from freezing. The amount of circulation may be very little. Mr. Routledge in one of his experiments found that as little a flow as 0.16 gallon per minute would keep a 6-in. uninsulated main from freezing when the temperature was 4 deg. above zero.

A great deal depends on what the temperature of the water is in the main where it is not exposed. If it is normally close to freezing a greater circulation of water is required in the exposed pipe.

It is our practice to place a blow-off close to the end of an exposed main so that it can be de-watered in a short time if required, as we have found that no amount of insulation will prevent a main from freezing if there is no water circulating in it.

We can always tell when an exposed main is very near freezing as we will have complaints of dirty water from the consumers nearby.

In a water main, when frost attacks it, the ice forms in the pipe first on the inside of the metal of the pipe. As the action progresses the ice accumulates on the perimeter and gradually closes in to the center. While this is going on all the tubercles and slime which ordinarily cling to the pipe are removed and forced to the center.

If the pipe is allowed to freeze completely, all the dirt will be found at the center of the block of ice. This accounts for the prevalence of dirty water just before the main finally freezes solid.

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Cost of Water Purification at St. Louis, Mo.

During the past 10 years the unit cost of purification at the filtration plant of St. Louis, Mo., has varied. It increased gradually until 1924 and then decreased steadily until 1929, when it increased again. August G. Nolle, Chief Chemical Engineer, Chain of Rocks Plant, states in the annual report (for year ending April 7, 1930) of Leonard A. Day, Water Commissioner, that the major factors in the general reduction of the unit cost of purification during the first nine years were the reduction in the price of chemicals and the increase in the amount of water delivered to the consumers. The major factor in the increased unit cost of purification during the last year was the decrease in the amount of water delivered to the consumers; this decrease in consumption being caused by the starting of the new Howard Bend Plant which relieved the Chain of Rocks Plant of a large share of its load. The following table shows the average unit cost of the various parts of the purification work for the ten year period and the per cent of the total unit cost of purification of these averages.

Average Unit Cost of Purification per Million Gallons Based on Consumption—1920-1930 Chain of Rocks Plant

Fiscal Year Ending March 31st	Average Unit Cost	Per Cent of Total Cost
OLD PLANT		
Lime	$3.62	33.5
Iron	.93	8.6
Unloading	.13	1.2
Operating, maintenance and repairs	.64	5.9
Water, coal, oil, etc.	.08	0.8
Light and power	.11	1.0
Chemical work and supplies	.49	4.6
Basin cleaning	.31	2.9
Basin repairing	.10	0.9
Switching and demurrage	.24	2.2
Total—Old Plant	$6.65	61.6
FILTER PLANT		
Aluminum sulphate	$1.92	17.8
Chlorine	.27	2.5
Operating, maintenance and repairs	1.14	10.6
Coal, miscellaneous supplies and expenses	.40	3.7
Light and power	.37	3.4
Switching and demurrage	.04	0.4
Total—Filters	$4.14	38.4
Total for purification	$10.79	100.0
Total consumption in million gallons	40,462	

The following tabulation itemizes various parts and shows the percentage of the total cost of each part itemized:

	Per Cent
All chemicals for purification	62.4
Labor—Operating, maintenance and repairs	16.5
Chemical work and laboratory supplies	4.6
Miscellaneous supplies and expenses	4.5
Light and power	4.4
Basin cleaning	2.9
Switching and demurrage	2.6
Unloading chemicals	1.2
Basin repairing	0.9
Total	100.0

The expenditure for chemicals alone of 62.4 per cent is controlled and supervised by a labor cost of only 4.6 per cent of the purification cost. The remaining 33 per cent is for operating, maintaining and repairing the combined purification equipment.

Deep Well Developments in Southern California

Approximately 80 Per Cent of the Water Supply Is from Ground Water; This Article Tells How Los Angeles Put in an Auxiliary Well System and the Method Adopted for Preventing Interference

By D. A. LANE

Assistant Engineer Bureau of Water Works Supply, Los Angeles, Calif.

IN the southern part of the city, the Los Angeles Water Bureau has recently put in an auxiliary supply of wells and attempted a novel plan to prevent interference with the present supply.

The old installation consists of four 16-in. wells varying in depth from 300 to 700 ft. The water level in these wells has dropped over 50 ft. in the past 25 years, 20 ft. of which was in the last 5 years. To increase the supply it was determined to drill two additional wells in the adjacent territory. Both wells are 16-in. diameter, one with a depth of 1,002 ft. and the other 1,203 ft. Neither one is perforated above 840 ft. The static level of these deeper waters is approximately 5 ft. lower than that of the old wells. No record of the fluctuation of those deep waters is available.

Due to the small number of wells in this area penetrating these deep gravels, this supply should remain constant for many years.

Types of Wells Now in Vogue.—There are three distinct types of well drilling being carried on in Southern California at the present time:

The old time standard well rig with the shoe from ⅞-in. to 1½-in. in thickness, and standard stovepipe casing in 3 or four ft. joints, perforated when the well is landed on bottom.

The next type called a "gravel envelope" well, using a standard rig and standard stovepipe casing, but with a cast-shoe of sufficient thickness to leave a space of several inches between the casing and the side walls of the hole. This space is kept filled with pea-gravel as the hole is put down, so that when completed the casing is entirely surrounded with a layer of gravel. The casing is then perforated and additional gravel fed in around the casing as the well is developed.

The other type of "gravel envelope" well is drilled with a rotary rig and equipment. Open hole is drilled for the entire depth of the well. Perforated casing in sections of a diameter several inches less than that of

Start of Development; Pumping Mud from 16-In Well 1,203 Ft. Deep. Only Gravels Below 800 Ft. Were Perforated

the hole is then set and gravel fed in between the casing and the hole. The mud is pumped out and a circulation of water gradually clears out the mud remaining in the gravel.

The principal advantage of gravel envelope wells lies in their ability to develop good producing wells in areas where sand or fine materials prohibit standard drilling methods perforating all strata. For this reason the gravel envelope will produce wells in areas heretofore impossible, while in other districts they may get an increased production by reason of their tapping additional stratum.

Logs of Wells.—The collection and study of several thousand well logs in the Coastal Plains of Southern California, has shown the variation in classification of the same materials, by various drillers.

Due to this variation, I would recommend that engineers or superintendents of water companies having wells drilled for them, either be on the job and personally identify the materials with log, or leave the matter of perforation to the driller. It has been my observation that the man who has his hand on the cable is better qualified to judge the materials than any one else.

Some engineers feel that they are not properly directing the work unless they issue the perforation instructions. I know of two instances, where the engineer in charge supplied the driller with a chart to perforate his well, without reference to the log of that well. "Why bother with the log of one well when he had logs of half a dozen in the vicinity to use as a guide."

Perforation of Wells.—The proper perforation determines the future production and value of the well more than any other factor. More wells have been lost through careless or improper perforation than any other reason.

There are many types of perforators on the market, but no new or radical developments have been made for many years. There are two general types now in use. The rolling disk type, cutting six rows of holes simultaneously, and the single blade type. The principal objection to the roller type is that it may have a point broken on one or more discs which will not be observed until the perforator is withdrawn from the hole, consequently the well is underperforated. It is utterly impossible to re-perforate with safety, and it should never be attempted until every other recourse has been taken. In many districts incomplete perforation means no well.

The single blade type, which requires an individual operation for every hole cut, has the advantage of the operator observing, by the feel, whenever a seam in the casing is encountered and the instant the blade is broken. When this occurs the only loss of perforation is the remaining cuts of the round.

The principal chance of trouble with the single blade is by a careless helper making two cuts in the same hole. In coarse material this may not be serious, but in sand and fine gravel it is disastrous. It is usually the result of too much speed on the part of the crew. My instruction to the crews are to "take your time in perforating, if it requires as long as the drilling of the well," for what is the cost of a few days time compared to the loss of a ten or fifteen thousand dollar well.

A chance for additional perforated area, often overlooked by drillers, is that of perforation from 3 to 5 ft. below a gravel stratum in a sand stratum. This allows the coarser materials to drop down and bridge off the sand, thereby increasing the yielding power of the well by including part of the sand stratum.

Methods of Development.—The method of development used with considerable success by the Department of Water and Power of Los Angeles, for several years, is a screw pump driven by a 6-cylinder, 125 hp. tractor engine.

The paramount advantage of the gas engine over other usual motive power is its flexibility of speed. This is a particular advantage at the beginning of the development when a minimum speed is desired to prevent the well from "breaking" suction. Each loss of suction means the deposit of sand in the bottom of the casing and the covering up of perforations. Once these perforations are covered they can only be opened up by the drilling scow or an air lift.

The Los Angeles Water Bureau has found that the most economical procedure of development is to keep the drilling rig over the hole until it is ready for the operating division.

The mast, by back-lashing the walking beam, may be used for setting and pulling the pump. Should a part of the lower perforations be cut off during developing, the pump may be quickly pulled, the hole cleaned, and the pump reset. The hole may also be cleaned after development and left ready for the permanent installation.

At the start of development the pump is started slowly and run at a constant speed until the water clears up. The engine is then speeded up slightly and maintained until the well again clears. This operation is repeated in succession until the maximum speed of the engine is reached.

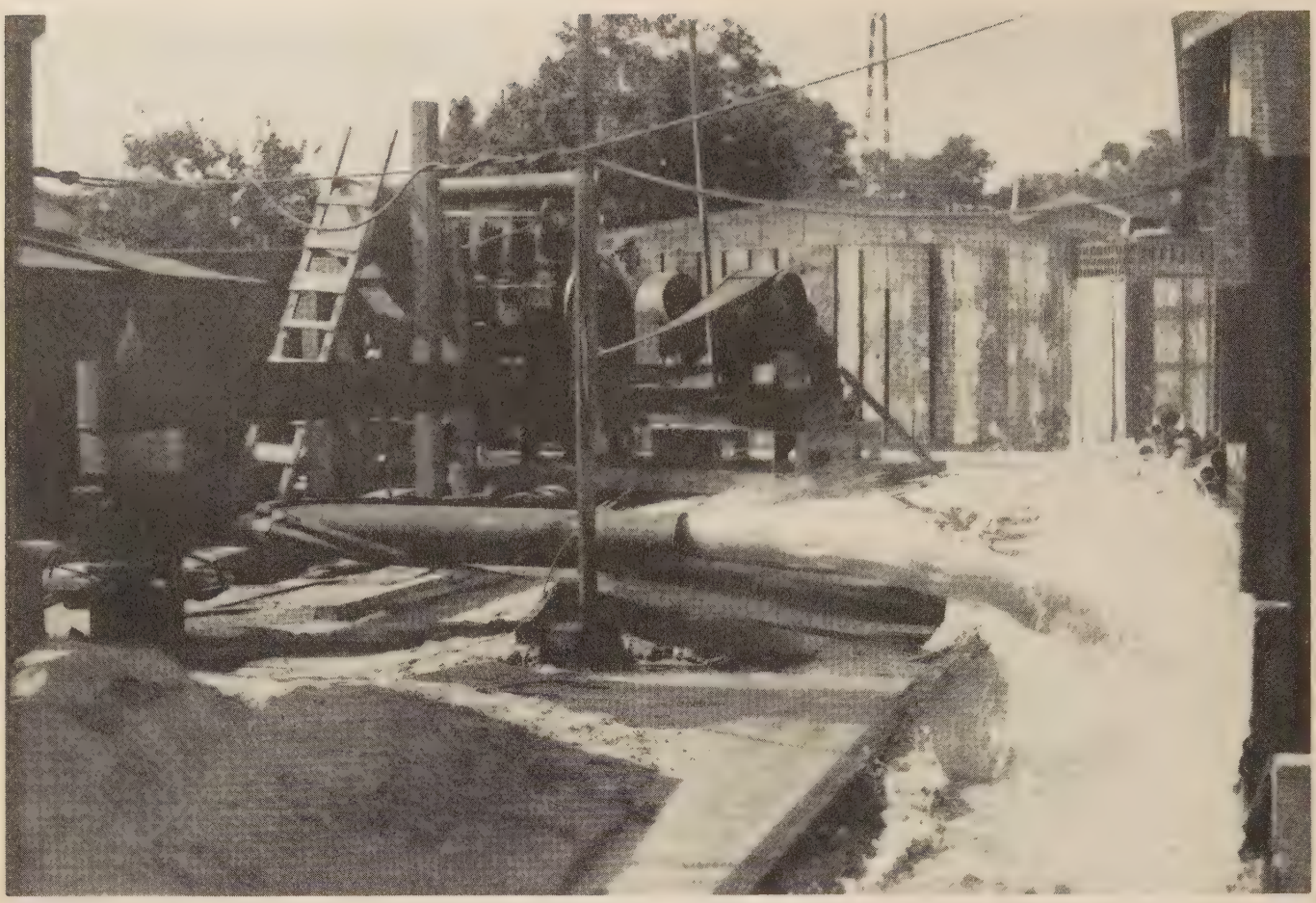
At this stage surging is commenced. The clutch is released quickly, allowing the entire volume of water in the pump to drop back into the casing. The instant the pump ceases to revolve backwards, the clutch is thrown in and the engine raced at full speed until the water reaches the ground surface. The clutch is again released and the operation repeated. The second or third surge will usually keep the well pumping for some time before clearing up. The value of this surging operation and its effect was demonstrated to us by some twenty-five wells drilled along the Los Angeles River bed and perforated to within 40 ft. of the surface. The water level stood at about 20 ft. below the ground surface. As the water returned to the well, there was seemingly no disturbance, but on the quick pickup after the surge the gravel for several feet surrounding the well would move in towards the casing.

Development of Wells with Air.—In many places, especially along the south coast where the water bearing gravels carry an excessive amount of sand, it is difficult to clean a well out after perforating. Air causes the least agitation of any method known and is very often used by installing a 6 or 8 in. eduction line down to the sand with an inch or an inch and a half air line inside. The drilling or developing crew is able to lower this line gradually as the gravel displaces the sand opposite the perforations. To obtain the best results the air line should be submerged at least seventy-five per cent. The education line however, can be lowered to the full depth of the well.

After the free flowing sand has been removed by the air lift, the developing pump may be installed and the well developed to capacity.

The principal disadvantage of air for complete development is the slow pickup and drop for surging.

Amount of Development Necessary.—Every well should be developed to its maximum capacity, regardless of the quantity it is desired to produce as a constant draft. A study of development curves of many wells



The Well Cleaned and Pumping 1,350 Gal. per Minute

drilled by the City of Los Angeles in various locations has proven this.

This is particularly true of wells to be operated on systems with small storage capacity or automatic pressure "cut-ins." Where the operating demand is near the maximum capacity of the well, this constant stopping and starting of the pump is usually a source of trouble to the system. The constant agitation of the water keeps a flow of sand into the well, a part of which is pumped into the system, and a part dropping into the bottom of the well. Eventually this means a sand pumping job and possible collapse of the well.

With the well developed to capacity, a production test may then be made. From this test a capacity and drawdown curve may be plotted, and a safe and economical operating schedule obtained.

Due to the meandering streams that laid down our Southern California valley fills, it is obvious that each well is a separate and distinct problem, to be dealt with and studied individually.

Acknowledgment.—The above is an abstract of a paper presented before the California Section of the American Water Works Association.

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Pacific Northwest Water Works Men to Meet at Vancouver, B. C.

The Board of Directors of the Pacific Northwest Section of the American Water Works Association have decided to hold the Fourth Annual Meeting of the Section in Vancouver, B. C., on May 14-15-16, 1931.

The Hotel Georgia has been tentatively selected for the headquarters of the meeting. Although not definitely settled at this time, the program will probably be similar to that followed in the past, with a golf tournament on May 14, a round table discussion being held at the headquarters on the same date. The business meeting will probably be held in the evening of May 14, followed by some speaker or other type of entertainment. The technical papers will probably be presented on May 15, with the dinner meeting and entertainment in the evening. It is planned that on May 16 an inspection trip over the Vancouver System will be the principal order of business and it is reported that many interesting and novel features will be under construction at that time and that they will all be available for inspection.

The following committees have been appointed in connection with this meeting:

Program Committee: Messrs. Ben S. Morrow, chairman, J. L. Stannard, and H. W. Nightingale.

Registration and Reception Committee: Messrs. H. T. Judson, chairman, Kenneth Shibley and H. A. Goode.

Local Arrangements and Entertainment Committee: Messrs. C. Brakenridge, chairman, W. B. Severyns, R. C. Polk, C. F. Klapp and A. Hardman.

Golf Committee: Messrs. E. W. Thompson, chairman, Albert H. Booker, Jr., R. A. Gridley and Jack Belyea.

Nominating Committee: Messrs. S. C. Watkins, chairman, R. E. Koon and C. C. Casad.

Ernest C. Willard, 720 Corbett Bldg., Portland, Ore., is secretary-treasurer of the Pacific Northwest Section.

Cost of Sewage Treatment at Worcester, Mass.

THE sewage treatment plant of Worcester, Mass., has now been in operation for over five years. Construction was started in 1919 and the plant was placed in service on June 25, 1925. The approximate cost was $3,800,000. The plant consists of grit chambers, screens, Imhoff tanks, dosing tanks, trickling filters, secondary settling tanks and sludge drying beds. The plant was designed to handle 28,000,000 gal. daily and for a population of 242,000 in 1934. Some interesting information on the operation of this plant in 1929 is given in the recently issued report of John H. Brooks, Jr., superintendent of sewers. The notes following are taken from the report.

Sewage Flow.—The quantity of sewage received at the plant was much less than that received in 1927 or 1928, a condition accounted for by the extreme dry weather. The total sewage flow was 7,580.45 million gallons, representing an average daily flow of 20.77 million gallons. The maximum daily discharge was 58.6 million gallons and the minimum was 8.6 million gallons. The estimated population using the sewer system was 190,000 and the average daily discharge per each user was 109.3 gal.; the maximum was 308.5 gal. and the minimum 45.1 gal.

Results of Treatment.—The operation of the plant was very successful during 1929. Treating a stronger sewage, due to dry weather, a final effluent was obtained which in almost all respects was better than that of any one of the four years that the plant has been in operation. The average amount of organic matter removed from the sewage measured by organic nitrogen was 73.0 per cent and by biochemical oxygen demand was 90.1 per cent. The final effluent was perfectly stable except during ten weeks of mid-winter. During four of these ten weeks, 50 per cent of the samples tested were stable.

Cost of Treatment.—The cost of sewage treatment in 1929 is summarized as follows:

	Total	Per Million Gallons
Screen	$ 2,153.26	$0.29
Grit chamber	752.88	0.10
Imhoff tanks	12,598.29	1.69
Trickling filters	7,572.57	1.02
Secondary tanks	8,890.91	1.19
Sludge disposal	15,032.54	2.01
Laboratory	8,607.09	1.15
Total	$55,607.54	$7.45
Real estate (credit)	774.37	

The cost of maintenance and operation of the plant based only on payroll charges at the plant was approximately $5.21 per million gallons of sewage treated by the plant. Including all materials and supplies, teaming and department transfers of labor, the department records show a total net expenditure of $55,607.54, representing a cost of $7.45 per million gallons of sewage treated by the plant. All sewage received at the plant passed through the grit chambers and was screened before treatment or by-passed to the final effluent channel.

The total net expenditure was only slightly more than in 1928, while the smaller quantity of sewage flow resulted in an increased cost of maintenance and operation per million gallons from $6.56 to $7.45.

Grit Chamber Cleaning.—There are two grit chambers with 2-in. bar screens. Two cleanings and ten flushings of the material were made for the grit chambers. The drying bed into which the flushings are made was cleaned once. The grit removed averaged 4.54 cu. ft. per million gallons of sewage. Each chamber was cleaned once per month, the grit removed being used to fill low places. The cost of cleaning averaged 64 ct. per cubic yard removed. The screenings removed averaging 2.37 cu. ft. per million gallons of sewage were buried in a low area near-by. The cost per cubic foot for removal and disposal was 11 ct. The screen attendance daily was normally 4 hours once and 1 hour twice. Table I gives data on grit chamber cleaning for four years. Table II gives screenings data for the same period.

Imhoff Tanks.—The Imhoff tanks, 12 in number, are 60 x 90 x 31 ft. deep. The total capacity of the sedimentation compartments is 2.43 million gallons. The average daily quantity of sewage treated in 1929 was 20.47 million gallons and the average period of detention was 2.8 hours. The volume of sludge produced per million gallons of sewage was 2,847 gal. The quantity of grease removed was 7,282 cu. ft. The Imhoff tanks cost $878,434 and the cost of maintenance in 1929 was $12,598 or $1.69 per million gallons of sewage treated.

Trickling Filters.—These have an area of 752.5 ft. by 792 ft. (13.68 acres) and are in four units. The film material is bastard granite, trap rock, 1 to 3 in. in size and 10 ft. deep. The nozzles are of the Worcester type, 13/16-in. orifice; there are 2,992 nozzles.

Table I—Grit Chamber Cleaning, 1926-1929

		Material Removed			Flushing and Cleaning				Flushing				Cleaning Drying Bed		
Year	Million Gallons Sewage Est.	Total Cubic Yards	Cubic Ft. per Mil. Gals.	Total Tons	Number Times E.	Number Times W.	Cubic Yards Removed	Cost Cubic Yard	Number Times E.	Number Times W.	Cubic Yards Removed	Cost Cubic Yard	Cubic Yards Removed	Cost Total	Cost Cubic Yard
1926	8212.5	1238.5	4.08	1300.4	3	2	360.1	$0.77	11	12	878.4	$0.08	552	293.55	$0.53
1927	7947.2	1192.6	4.05	1252.2	2	2	225.9	0.47	11	11	966.7	0.12	1090	646.21	0.59
1928	8705.9	1362.6	4.21	1432.8	3	3	407.1	0.62	10	10	957.5	0.12	1026	463.64	0.45
1929	7580.5	1276.2	4.54	1340.0	2	2	301.2	0.57	10	10	975.0	0.15	961	495.17	0.52

Cost figures—labor payroll at plant.

Table II—Screenings Data, 1926-1929

	Sewage Million Gallons		Screenings Cubic Feet			Tons		Cost		
Year	Total, Est.	Day	Total	Day	Mil. Gals.	Total	Day	Total	Day	Cubic Foot	Mil. Gals.
1926	8212.5	22.50	16071	44.0	1.96	538.3	1.47	1916.83	5.25	0.119	0.233
1927	7947.2	21.77	14226	38.9	1.79	476.5	1.31	1827.93	5.02	0.129	0.231
1928	8705.9	23.79	15723	42.9	1.80	526.7	1.44	1887.82	5.16	0.120	0.216
1929	7580.5	20.77	17965	49.2	2.37	601.8	1.65	1917.97	5.25	0.107	0.253

Cost figures—labor payroll at plant.

Table III—Trickling Filter Operation, 1929

1928-29	Trickling Filter Influent Million Gallons Daily: Total Million Gallons	Average	Maximum	Minimum	Average Acres Filters in Service	Million Gallons Treated per Acre per Day: Average	Maximum	Minimum	Nozzles Cleaned: Total	Per Day	Per Acre Per Day
December	579.95	18.71	24.35	14.79	13.61	1.37	1.96	1.09	8906	287	21.0
January	672.17	21.68	37.40	15.64	13.68	1.59	2.73	1.14	8205	265	19.4
February	581.58	20.77	33.97	14.55	13.68	1.52	2.48	1.06	7638	273	20.0
March	682.58	22.02	33.32	13.24	13.60	1.61	2.44	0.97	8733	282	20.6
April	868.78	28.96	36.61	18.17	13.67	2.12	2.68	1.33	7641	255	15.2
May	838.74	27.06	33.53	20.29	13.68	1.98	2.45	1.48	8080	261	19.1
June	571.65	19.05	23.04	13.00	13.68	1.39	1.68	0.95	5132	171	12.5
July	517.20	16.68	19.86	11.02	13.67	1.22	1.45	0.81	5224	188	13.7
August	488.34	15.75	19.27	10.47	13.60	1.16	1.42	0.77	6119	197	14.4
September	476.97	15.24	20.80	8.56	13.67	1.12	1.52	0.63	4035	135	9.9
October	495.29	15.98	27.44	11.70	13.57	1.18	2.01	0.86	8349	269	19.8
November	489.00	16.30	24.95	12.02	13.68	1.19	1.82	0.88	9023	301	18.5
Average	7262.25	19.90	37.40	8.56	13.65	1.46	2.73	0.63	87685	240	17.6

Contributing population per acre foot—1460.

Table IV—Sludge Disposal Data—1929

Month 1928-29	Beds Cleaned	Machine Hours	Cubic Yards Removed	Cost of Operation: Gasoline	Foreman	Labor	Teams	Per Cubic Yard
December	3	117 1/3	1,338	20.00	23.10	242.45	513.80	0.598
December	1*	.....	1,004	.....	26.40	354.47	359.45	0.737
May	3	106	1,201	17.40	34.10	246.35	402.15	0.583
June	3+	174½	2,447	28.90	82.50	437.13	875.18	0.582
July	2+	192½	2,343	28.90	96.25	568.26	1,017.45	0.730
July	4*	.....	1,817	.....	36.30	466.34	438.37	0.518
August	4—	197	2,385	28.62	50.60	478.83	759.68	0.552
September	0+	10	99	0.90	2.20	21.76	33.60	0.591
September	4*+	.....	2,129	.....	63.80	601.64	583.28	0.587
October	5—	122	1,302	21.00	36.30	294.70	297.15	0.499
November	1+	88	948	12.00	31.90	207.20	277.20	0.557
November	1+*	.....	916	.....	20.90	319.11	245.70	0.609
	33	1,007.3	17,929	157.62	504.35	4,238.24	5,803.01	0.597

*Sludge removed with forks.
Cost figures—labor payroll at plant.

The total cost of the trickling filters was $1,375,544 and the cost of maintenance in 1929 was $7,572.57.

The trickling filters were in continuous service throughout the entire year with excellent results. The total quantity of Imhoff tank effluent treated by the filters was 7,262.25 million gallons, an average of 19.90 million gallons per day or 1.46 million gallons per acre per day. The decreased quantity of filter influent as compared with 1928 represents 2.2 million gallons per day Data concerning filter operation is given in Table III.

Filter operation has followed the usual routine from day to day with one exception; the filters have not been harrowed in the spring and fall. The total number of nozzles cleaned was 87,685, an average of 240 per day or 17.6 per day per acre in use. This is a large increase as compared with last year and has been uniform throughout the entire year. Leaves together with unusual cold temperature during November resulted in a Monday cleaning of 2,600 nozzles or 87 per cent of the total number of nozzles in use.

Secondary Settling Tanks.—The secondary settling tanks are four in number and are 60 x 120 x 15 ft. deep. They cost $129,491 and the cost of maintenance in 1929 was $8,890.91.

Sludge Disposal.—There are 22 sludge drying beds, the total area being 21.95 acres. They are cleaned by means of a Barber-Greene loader and horse drawn dump wagons. The sludge is placed on a dump adjacent to the drying beds. A total of 17,929 cu. yd. of dried sludge was removed in 1929. The cost of sludge removal (excluding mixture charge) was $10,703 or 60 ct. per cu. yd. Table IV gives data on this.

Alkalinity Determination with Xylene Cyanole and Methyl Orange

The following note is taken from the report of August G. Nolte, Chief Chemical Engineer, Supply and Purifying Section, Chain of Rocks Filtration Plant as embodied in the 1930 annual report of Leonard A. Day, Water Commissioner of St. Louis, Mo.

During the year a centrifuge was purchased and all alkalinity determinations are now made on centrifuged instead of raw or filtered samples; consequently results now obtained show more true alkalinities than before because of the reduction in the amount of colloidal matter.

When determining the total alkalinity of a water using methyl orange as the indicator, the end-point is not sharp and a person making occasional determinations finds some difficulty in seeing the change at the end-point.

A mixture of xylene cyanole and methyl orange, containing 2 grams of methyl orange and 2.8 grams of xylene cyanole per liter, is sold by the Eastman Kodak Co., to be used instead of methyl orange alone. The xylene cyanole produces a bright blue color when dissolved in water and this color is not affected by slight excess of acid or alkali. The blue color accentuates the color change of the methyl orange and makes the end-point easily seen. The color produced by the above mixture is so pronounced, that the end-point is not sharp when fiftieth-normal acid is used for titrating and the results obtained are uniformly higher than when methyl orange alone is used. By decreasing the amount of methyl orange to 1.5 grams and the xylene cyanole to 0.35 gram per liter, an indicator yielding a sharp end-point, easily seen, results. One drop of the indicator is used for 100 milliliters of solution.

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Forecasting Rainfall by Correlation Methods

THE most successful method of long-range weather forecasting in use by weather bureaus is what may be termed the correlation method. The summer wet monsoons of India, for example, have been quite successfully predicted several months in advance by formulas based on temperature and pressure in other parts of the world. Our own weather bureau has not yet put into use such methods, although it has published several articles showing very striking correlations. One of the best of these articles is by George M. French, in the Monthly Weather Review, March, 1927, entitled, "March Temperature and the Following Season's Precipitation in Costal Southern California." Mr. French shows that at Los Angeles from 1878 to 1925, departures of mean temperature in March from the March normal are usually followed by departures in rainfall during the seasonal year starting the following June and ending a year later, and that these departures are of the same sign. Thus the mean temperature in March, 1930, was 3.3 degs. above the normal for March, which forecasts a rainfall above normal for the year ending June 30, 1931.

Mr. French's correlation theory held good in 74 per cent of the 48 years embraced in his analysis of Los Angeles weather, and we find that in the four subsequent years the ratio of 3 out of 4 was preserved. The odds are therefore 3 to 1 that the rainfall at Los Angeles will be supernormal during the 12 mos. ending June 30, 1931. A probability calculation shows that the odds are 2545 to 1 against an accidental correlation in the 38 out of 52 years that have passed since such weather records have been kept in Los Angeles. This firmly establishes a cause-effect relationship between Los Angeles temperatures in March and rainfall during the following "seasonal year."

The question naturally rises as to the nature of this cause-effect relationship. It seems to us to be inexplainable on the conviction hypothesis, for two reasons: First, because the correlation holds true only as to the temperatures in March. Second, because rainy weather in Los Angeles is accompanied by a drop in temperature. If subnormal March temperature were followed by subnormal rainfall, it could be argued that a rainy March portends a prolongation of a rainy period; but the correlation that Mr. French has found is one between a hot March and a subsequently rainy period whose maximum is 10 months later.

The editor has found many weather maxima and minima in March and in September that can not be explained on the theory of the seasonal march of the sun's rays, but that can be explained on the electron theory. On Mar. 8 the sun's south pole points most nearly earthward, and on Sept. 8 its north pole points most nearly earthward. The sun, by virtue of its axial rotation and the presence of free electrons, is an electromagnet. The sun's magnetic fields are periodically affected by the planets, hence any solar change that is occurring in March would be certain to make itself felt somewhere on the earth at that time. Apparently the activity of the permanent anticyclone between California and Hawaii is thus affected to a sufficiently marked extent in March to cause temperature changes in California. Thus events coming the following rainy and cool season cast their shadows in March.

Probably other weather correlations that are usable in long-range forecasting have a similar explanation. Certainly the attempts to explain them by the connection current hypothesis are anything but convincing.

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Financing Improvements Out of Earnings

AN ideal business is one that pays a fair return on the capital invested in it and at the same time earns enough to furnish capital for betterments and growth. Sir Thomas Lipton, in a recently published article, said that he had built up his great business without borrowing money or selling stock. Its earnings had been sufficient to finance its rapid growth, in spite of strong competition.

It seems to us that such examples of successfully conducted private business furnish a lesson for municipally owned utilities. By moderately increasing the rates charged for water, most of our towns and cities could earn enough to finance ordinary additions and improvements not only of their waterworks but of their sewerage systems. We include sewerage because, in the final analysis, waterworks and sewers are so closely related as to form one hydraulic system. Indeed most of the water supplied to the typical municipality is used to carry away wastes and excreta.

The burden of real estate taxation has become so great in most cities that many organizations are vigorously opposing any further increases in such taxes. Many bond issues for waterworks and sewers were defeated in the recent elections, not because the projects lacked economic merit but solely because tax payers were already burdened beyond the limit that they were willing to endure.

Not many years ago it was impossible to secure enough money for badly needed road improvements, because tax payers so frequently refused to endorse proposed bond issues. Then came the gasoline tax that has proved so effective in raising funds for our highways. Tax payers who would have refused to vote for highway bonds were willing to pay 10 to 15 per cent

more for gasoline, provided that the 10 to 15 per cent were to be used for road improvement.

We feel confident that most tax payers will not oppose a 15 per cent increase in rates charged for water, if they are assured that the additional money thus secured will be used for such additions and improvements to waterworks and sewers as are economically justified.

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Is Consulting Engineering Service by Correspondence Feasible?

THE general practitioner is slowly becoming extinct in America, for specialists have shown superior ability in almost every realm where scientific knowledge is exercised. In the medical world the "family doctor" may linger for a while, and he will linger longer if he confines his practice to diagnosis, but even diagnosticians are becoming specialists, some confining their diagnostic work to one sort of disease, some to another sort.

Civil engineering is steadily becoming more highly specialized, but the "family doctor" type of civil engineer is still numerous. A small community can not support very highly specialized men in any profession. The small town engineer, like the small town doctor, must take any "case" that comes along, or he will not have enough income to support him. Yet there should be some relatively inexpensive way by which such general engineering practitioners could secure the aid of specialists. Very frequently they do not appreciate the need of such aid; for since they seldom come in contact with specialists they are apt not to realize that only by specialization can any professional man keep abreast of scientific progress.

In the medical world skill that comes from practice must be added to knowledge that comes from study. There, perhaps above most other professions, a general practitioner is severely handicapped. A country doctor who has but one pelvic fracture to treat in a year is clearly less competent to handle such a case than a city specialist who reduces one a week. Yet it is noteworthy that country doctors usually undertake to set the most difficult fractures and even to perform delicate operations that they have no ethical right to perform. To less degree is the general civil engineer blameworthy for undertaking the design of any sort of a structure, for in his case human "life and limb" are seldom at stake. However, someone's money is always at stake when an engineer is employed, and, we repeat, the advice of an engineer specialist should usually be secured. But how?

As engineer specialists now operate, rarely do they undertake a job without visiting the site of the work. This alone may involve an amount of time that results in excessive cost for their services. Would it not be feasible for the specialist to dispense with visits to the construction site of small jobs, in most instances, and to give his advice by letter?

Some years ago the editor conducted a weekly page on engineering specifications in which he offered suggestions and criticisms. Hundreds of specifications were sent to him from all parts of America, asking for criticism. This experience demonstrated that many general practitioners in civil engineering were anxious to secure advice. The editor did not pretend to be "a know it all," but merely claimed to have studied the use of words and the application of certain economic principles.

Ambiguity is a common error in writing a specification. This at least can be avoided by a specialist in language. Then, among economic mistakes, there is one that is found in many contracts relating to public works, namely the mistake of trying to load all uncertainties upon the shoulders of the contractor. For example, the contractor may be required to bid a unit price on unclassified excavation. If he is fearful that more rock will be encountered than is indicated by surface conditions, his bid may be very high. Contrariwise, if he is too optimistic. In the long run it is uneconomic to award contracts to bidders whose bids are too low to yield a profit. At no time is it economic to pay excessive prices for work. So, viewed from any angle, it is uneconomic to require contractors to "bid in the dark." While it may seem that this principle is self-evident, the frequent failure to apply it indicates either that it is not self-evident, or else that many an engineer is unduly fearful as to lawsuits resulting from disputes over classification of specifications. Incidentally such disputes are usually the result of ambiguous specifications, so we come back to the use of language as an art that is itself highly specialized.

Perhaps not one man in ten, even among educated men, realizes that he is frequently ambiguous in his writing and talking, and that only long study and practice develop great clarity of expression. We are not now speaking of rhetorical elegance. Few engineers lay claim to being skilled rhetoricians. But in common with the vast majority of men, engineers usually regard themselves as being able to convey their ideas clearly. While we believe that engineers excel nearly all professional men in clarity of expression, we regard lawyers as being greatly the superior of engineers in the use of unambiguous language. Of course the average lawyer should be the superior of the average engineer in this respect, but the very admission of that superiority is sufficient to show the need of a review of every specification by an engineer skilled in the use of language relating to construction. Lawyers usually lack knowledge of construction terms, hence are not as good writers of specifications as engineers who have specialized in that art.

It is not difficult for a specification specialist to review almost any specification quickly and without visiting the site of the work. Hence, the cost of such a review need be only nominal. We raise the question whether an approach to such nominality of cost may not be obtainable as to a review of the design of small structures. If it can be thus secured, then there may develop valuable consulting engineering service by correspondence.

Possibly the typical engineer is much too self-reliant; and, if so, consulting engineering service by correspondence would probably not be sufficiently remunerative to attract able specialists. But our one-time experience with advice on specifications, leads to the belief that there is a latent field for engineering consultation by letter.

H. P. Gillette

THE TELEPHONE BRINGS THE ADVANTAGES THAT COMFORT AND CONVENIENCE GIVE TO LIVING

This is the telephone's mission

An Advertisement of the American Telephone and Telegraph Company

In this country, a new type of civilization is being reared—a civilization of better opportunity for the average man, comfort and convenience, business enterprise and higher standards that enrich the daily life of all the people.

To build for this new age, the Bell System in 1929 expended more than 550 million dollars. These millions were used to add new plant and further improve service. Hundreds of new buildings, millions of miles of wire, chiefly in cable, eight hundred thousand new telephones—these were some of the items in the year's program of construction. At the same time, better records were made for speed and accuracy in service.

This American development of instantaneous communication, of fast, far-reaching speech, belongs not to the few, but to the many.

It is the aim of the Bell System to permit each personality to express itself without regard to distance.

This is part of the telephone ideal that anyone, anywhere, shall be able to talk quickly and at reasonable cost with anyone, anywhere else. There is no standing still in the Bell System.

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Link-Belt Opens Vancouver Branch Office

Link-Belt, Limited, recently opened a branch office in the Standard Bank Building, 510 West Hastings St., Vancouver, B. C., placing their experienced engineer, Mr. Frank B. Wetherill, in charge.

Mr. Wetherill joined the Link-Belt organization 15 years ago, and for a number of years has been manager of the company's office and warehouse in Portland, Oregon. He is well versed in the application of materials handling and power transmitting machinery to the needs of industry in the Pacific Northwest.

Frank B. Wetherill, Manager, Link-Belt, Ltd., Vancouver, B. C.

In establishing this new office, announcement states that it is the aim to supplement the service which has been rendered through Fleck Bros., Ltd., Canadian Fairbanks-Morse Co., Ltd., and A. R. Williams Machinery Company, Ltd., who, it is stated, will continue as official distributors of Link-Belt chain and other merchandise material.

Mr. Wetherill will not only make use of the large manufacturing works at Toronto and Elmira, Ontario, but will have available the plants, warehouses and engineering facilities of the Pacific Division, Link-Belt Company. The nearest shop and warehouse of this division is located in Seattle, Washington.

The Trend of the Times

Better distribution of materials and supplies is a definite trend of the times and interested manufacturers are eagerly seeking ways to follow this trend, which is a logical step in the simplification program which was fostered by President Hoover while he was Secretary of State.

One result of this movement toward better distribution is the locating of large stocks of standard parts required by industry, in strategic centers throughout the country—a result which benefits both the maker and user. Coupled with the trend toward simplification, it reduces losses formerly incurred by users in paying premiums of time and money for special goods shipped from distant points.

An exponent of this modern distribution efficiency is the Link-Belt Company, Indianapolis, Indiana, known for over 50 years as a manufacturer of power transmission and materials handling equipment. For the past six years their distributors have carried in stock their silent chain drives. They now announce a further extension of power transmission service by arranging with their local distributors for the stocking of Link-Belt roller chain drives (the two wheels and the chain). It is believed that this stepping up of service will add in point of economy and convenience because of the large percentage of power transmission jobs employing these types of drives.

To enable users to take fullest advantage of this service, Link-Belt has further prepared an entirely new data book, giving information and tables from which the user can select the drive needed for his purpose and order from the nearest distributor.

M. D. Tracy Joins Headley Company

Headley Emulsified Products Company, manufacturers of emulsified asphalts, announces the appointment of M. D. Tracy as general sales manager.

Mr. Tracy brings to their organization an excellent merchandising and selling record extending over a number of years as sales manager for The White Company, and later, General Motors Truck Company.

Mr. Edgar S. Ross, president of the company, states that an extensive national sales and distributing organization will be developed as well as South American and foreign trade.

Offices of the company are in the Franklin Trust Building, Philadelphia, with plants at Marcus Hook, Pennsylvania, and Memphis, Tennessee.

Inland Steel Arranges for Acquisition of Coal Mine

Subject only to the investigation of titles and other legal requirements, the Inland Steel Company has purchased from Elk Horn Coal Corporation the latter's Wheelright Mine with its plant and equipment in the Eastern Kentucky coal district, and has leased from the Elk Horn company about 11,000 acres of coal, according to statement of Mr. J. L. Block, vice-president of the Inland Company.

Announcement states that substantial improvements will be made in the plant and equipment to bring production up to approximately one million tons per year. This will give the Inland Steel Company an adequate reserve of high grade by-product coal, it is said.

Clarence W. Hodges

Mr. Clarence W. Hodges, general purchasing agent of the Worthington Pump and Machinery Corporation died at Paterson, New Jersey, on January 17th. Although he was seemingly in the best of health, he was taken suddenly ill and died at the Paterson Hospital as the result of an operation.

Mr. Hodges was born at Randolph, Vermont, May 15, 1876, and was graduated from Williams College with the class of 1900. For some years he was employed by the American Locomotive Company as purchasing agent, and since 1918 he had been employed in the same capacity by the Worthington Corporation.

Funeral services were held at the West Side Presbyterian Church, Ridgewood, New Jersey, on January 19th, and burial was at Randolph, Vermont. Mr. Hodges was a member of the Phi Gamma Delta Fraternity and of the Ridgewood Country Club. He is survived by his widow and four sons.

20 miles of . . . . . 48-inch mains will keep Albany abundantly supplied with water

CAST Q IRON TRADE MARK

One of the finest and largest water supply systems in the country is now in course of construction for the city of Albany, New York. Two lakes with a total capacity of more than twelve and one-half billion gallons are being built twenty miles up in the hills. To carry the water from these lakes, the engineers and city officials agreed on the specification of a cast iron conduit 48 inches in diameter and twenty miles long.

This giant water main is estimated to have a load capacity of 45 million gallons per day, or more than twice the needs of the present city. In other words, this main is planned to supply abundant water when Albany has grown to twice its present size—fifty or one hundred years from now.

Cast iron pipe was specified for this Albany job for the same reason that it is being chosen by many other enterprising cities, *its proved durability*. Cast iron has a record behind it which no other underground pressure pipe material can equal. There are cast iron mains in active service today which were laid more than a century ago.

Cast iron pipe marked with the "Q-check" symbol, as shown above, is produced by modern methods in accordance with established technical specifications. This "Q-check" symbol has been adopted as the trade mark of The Cast Iron Pipe Research Association.

For further facts about cast iron pipe write to Thomas F. Wolfe, Research Engineer, Peoples Gas Bldg., Chicago.

The Cast Iron Pipe Research Association is a service organization of leading pipe founders, formed to promote the scientific improvement and use of cast iron pipe. Pipe bearing the "Q-check" mark may be obtained from the following: Alabama Pipe Company, Anniston, Ala.; American Cast Iron Pipe Company, Birmingham, Ala.; James B. Clow & Sons, 219 N. Talman Avenue, Chicago, Ill.; Donaldson Iron Company, Emaus, Pa.; Glamorgan Pipe and Foundry Company, Lynchburg, Va.; Lynchburg Foundry Company, Lynchburg, Va.; National Cast Iron Pipe Company, Birmingham, Ala.; United States Pipe and Foundry Company, Burlington, N. J.; Warren Foundry and Pipe Company, 11 Broadway, New York.

CAST IRON PIPE

Peerless Pump Increases Service Facilities

A lease has been taken on the More-Pak Building, located at the corner of Sacramento and H Streets, Fresno, California, in order to give them increased facilities for furnishing service in the northern part of the state.

Floor area in the new building is said to be approximately 25,000 square feet. The building is being remodeled and will contain a fully equipped machine shop and assembling plant to take care of all kinds of pump repair work and service. A complete stock of parts will be on hand and a complete pump can be assembled and installed on twenty-four hours notice.

Sales and service from this branch of the Peerless Company will be in charge of Mr. L. A. Harnish, who for the past four years has served the company in this capacity. He has at his disposal a large staff of men and cars to care for service and make installations of new units.

Shop work will be under the direction of Mr. A. J. Anderson, who for some time was in charge of the San Jose branch. Twelve men are kept busy in the field service department, and it is expected that ten to fifteen first class mechanics and machinists will be employed in the shop.

Mr. E. F. Lewis who has been in the deep well turbine pump business for twenty-six years is the vice-president of the Peerless Pump Company, and Mr. Walter A. Johnson, another pioneer in the deep well pump industry, is the sales manager. Mr. J. R. Gilbert is assistant sales manager, and Mr. O. F. Blabon, who has been associated with the company for several years is chief engineer.

It is stated that many new and improved features are incorporated in the latest models of Peerless Pumps, and several new units have been added. Peerless units range in size from the new Peerless Junior delivering from 25 to 200 gallons per minute, up to those giving from 150 to 9,000 gallons per minute.

The latest Peerless pumps will be on display at the new headquarters in Fresno where the officers will be pleased to greet their friends and show them the "works."

Roots Merges

The P. H. & F. M. Roots Company, original patentees and for seventy years manufacturers of Rotary Positive Blowers, Pumps and Meters has merged with other interests and is now under the control of the Stacey Engineering Company of Columbus, Ohio, according to recent announcement.

The new organization includes the P. H. & F. M. Roots Company and the Connersville Blower Company, both of Connersville, Indiana, the Wilbraham-Green Blower Company of Pottstown, Pennsylvania, and the Stacey Brothers Gas Construction Company of Cincinnati, Ohio.

Heading the list of officers, Colonel Carmi A. Thompson, of Cleveland, was elected president; Corwin Abbott, vice-president and general manager; Fletcher S. Heath of Columbus, Ohio, vice-president; and Erle G. Meeks, secretary and treasurer. Charles T. Gordon will continue as general superintendent. Announcement states that Mr. E. D. Johnston, who for the past forty-five years has been connected with the P. H. & F. M. Roots Company, has resigned as president of the company and has retired from active business.

The new board of directors consists of Colonel Thompson, F. S. Heath and C. A. Ward of Columbus, Ohio, W. B. Stacey of Cincinnati, J. T. Wilkin, Corwin Abbott and Charles T. Gordon of Connersville.

All companies involved in the merger will maintain their separate identities and organizations, and will continue to operate separately until the final plans of the merger can be consummated.

A. M. Byers Co. Increases Sales Facilities

Some time ago the A. M. Byers Company started on a program of expansion on a wide scale to meet the increasing demand for wrought iron pipe, and as a further step in the expansion program announcement has just been made by Mr. L. M. Johnston, executive vice-president, of a reorganization of sales and distributing facilities throughout the country.

The new arrangement calls for realignment of sales territories, involving the promotion of nine members of the Byers organization to division managerships. The following statement has been issued by Mr. Johnston:

"Figures just compiled for the close of the calendar year show a continued and marked growth of demand for the special services rendered by wrought iron, particularly where corrosion and vibration are problems. The increases are especially notable in standard sizes for home and building installations and replacements.

"The program we have undertaken with regard to our sales and distributing organization is designed to improve and speed up service for builders and contractors, as well as for the marine, railroad and oil industries and other special fields."

Mr. Johnston further states that the new ten million dollar plant which the Byers Company is erecting just north of Ambridge, Pennsylvania, is nearing completion, and will be devoted exclusively to the production of wrought iron by the "Byers New Process" developed by Dr. James Aston, consulting metallurgist for the Byers Company and director of the department of mining and metallurgy at Carnegie Institute of Technology.

The nine division headquarters of this company, and their managers are: Boston, A. A. Gatheman; New York, G. W. Hamill; Philadelphia, J. C. Chaffe; Atlanta, A. D. Sheere; Houston, H. B. Weathersby; Pittsburgh, G. E. Clifford; Chicago, M. G. Henderson; San Francisco, H. K. Browning; Tulsa, F. W. DeLuce. Railroad business remains under the direction of J. H. Ainsworth, director of sales, with headquarters in Pittsburgh.

Industrial Equipment Offers Service in Far West

One of the well equipped distributor organizations in the far west is that of the Industrial Equipment Company, located at 360 E. Morrison St., Portland, Ore.

For manufacturers who wish to maintain an agency and carry stock in Portland, they offer centrally located display and storage space, and stenographic and telephone service. Separate office space is offered to manufacturers' representatives who wish their own offices, and wires, telephone calls and mail coming to them during absence from city are cared for by the Industrial Equipment office force.

The warehouse of this company is located on a spur track, well situated with reference to freight sheds, and the company has facilities for packing and shipping. They are now representing the McCormick-Deering Tractors, The Trackson Company, Bay City Shovels, Inc., Skagit Steel & Iron Works and Willamette-Ersted Company. Mr. Edward S. Marnon is manager.

Announcement

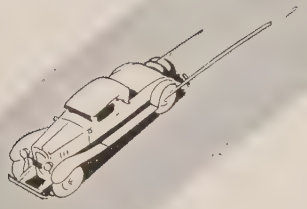
The United States & Foundry Company of Burlington, New Jersey, has issued an announcement concerning deLavaud pipe.

They state that it seems to be the general belief that deLavaud pipe is manufactured only in the thicknesses and weights prescribed in the United States Government specifications.

Announcement states that their company is constantly furnishing this product in strict accordance to the thicknesses and weights of the American Water Works Association and American Gas Association specifications, and they are equipped to manufacture any thickness or weight that may be required.

Chain Belt Company sales for 1929 are announced as just over eight million dollars. This is nine hundred thousand dollars more than in 1928, according to C. F. Messinger, General Sales Manager. It is expected that the Chain Belt Company's earnings for 1929 will be $7.00 per share. For 1928, they were $5.27, and the average for five years is $5.10.

IMPROVE YOUR OLD ROADS



Save Money on Construction and Upkeep

Dirt roads and gravel roads can be made into year 'round, farm-to-market highways with various treatments combining mineral aggregate with asphalt road oil or cut back asphalt.

Such roads are possible with a small appropriation. The present surfacing is not discarded, but is used as a base. The county already has the equipment to do the work. This work requires little labor, as most of it is done by machinery.

These roads are durable. The material is not blown away, but is conserved — it is left on the ground. The road is made better through use.

Thousands of miles of roads in hundreds of counties in the Middle West have been improved with the above treatments, and given complete satisfaction. Because of their low cost, durability and economy of maintenance, such improved roads can be had in your county — this year.

Mail the coupon below for specifications and full information.

Minnesota State Highway. Treatment of subgrade with Standard Asphalt Road Oil. Note smooth, dustless surface which is in good condition throughout the year.

South Dakota Highway. Three inches of gravel being treated with Standard Asphalt Road Oil by the mixed-in-place method. This method insures a durable, year'round riding surface.

Linn County, Iowa, September, 1929. Stanolind Cut Back Asphalt retread just after the keystone has been applied. This method of road improvement is an economical way of salvaging your old road bases.

Four proven road treatments, one of which will fit into your road surfacing program

Preparing Sub-grade with Standard Asphalt Road Oil prior to the application of gravel. When subgrades are treated by this method and covered with 350 cubic yards of gravel per mile, the asphalt road oil does two important things: it holds the gravel in place, and waterproofs the subgrade.

Mixed-on-the-Road Method. An untreated gravel road carrying 500 cars a day loses approximately an inch of surface a year through dust, which is costly waste. You can treat three inches of this gravel by the mixed-in-place method as cheaply as you can maintain the gravel road. When Standard Asphalt Road Oil is specified, the surface obtained will be hard and smooth the year 'round.

Surface Treating of Hard Surfaced Roads, such as compacted gravel, crushed rock and other hard surfaces, with Stanolind Cut Back Asphalt is an economical way of maintaining these roads. It entirely eliminates dust and cutting up in bad weather.

Stanolind Cut Back Asphalt Retread (or mixed-in-place method) is a practical method for building a wearing surface on present road bases. This type of road is easily and quickly constructed. It is non-skid and durable. The cost comes within that of building standard low cost improved roads.

Standard Oil Company
(Indiana) 226

Standard Oil Company *(Indiana)*, Room 1219
910 South Michigan Avenue, Chicago, Illinois
You may send me specifications and plans for improving secondary roads with Asphalt Road Oil and Cut Back Asphalt.

Name .....
Address .....
City ..... State .....

Asphalt and Road Oil for Low Cost Improved Roads

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For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Distributor thoroughly familiar with bituminous materials and equipment for handling, wishes to add to present lines. Covers Wisconsin and Illinois territory.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Distributor covering New Jersey and New York territory would like to secure a line of street markers or other traffic equipment on exclusive basis.

Equipment distributor in Pacific Northwest desires line of road building equipment, structural building equipment, dump bodies and truck hoists.

Distributors of contractors' and builders' machinery and equipment are seeking line of road forms, road finishers, batcher plants, clamshell buckets and drag line buckets, for northern California terirtory. Now stocking equipment for several well known machinery manufacturers.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Road machinery distributor would like to secure exclusive sales rights for state of Mississippi for line of automatic or self-loading wheeled scraper.

A Michigan distributor, with many years' experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing increased facilities in this region.

Manufacturers' representatives located in New York would like to add line of heavy contractors' equipment of established reputation, other than the lines now handled by them. They would like exclusive sales rights for such equipment.

Equipment distributor located in Michigan desires to add two or three good lines to serve territory in southeastern part of state.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Distributor of building specialties covering a territory of 100 mile radius from Chicago is equipped to represent additional lines.

Machinery distributor established in Porto Rico and Santo Domingo would be pleased to make arrangements to take on new lines in these territories.

Machinery company in the east is interested in representing established lines of road machinery, with the exception of graders.

Representatives Wanted

One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

Manufacturer of paving expansion joints is seeking distributors and manufacturers' agents in good, unassigned territory.

Manufacturer of air compressors and contractors tools has number of desirable territories open. Full co-operation will be extended to distributors.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of truck, adapted to many uses, has attractive territory open in Missouri, Kentucky, Kansas, Nebraska and several southern states.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

Manufacturer of excavating equipment desires to build up distribution organization throughout the country.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of hoisting machinery and air compressors has open territory in New York and New England states for aggressive distributor.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Attractive territory available for experienced men to handle contractors' labor-saving equipment by old established company. Equipment backed by national advertising.

A manufacturer of paving expansion joints is looking for distributors for northern California territory.

Manufacturer of metal lath, corner beads, channels and reinforcing mesh desires to secure distributors for products in the southwest and middlewest.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Manufacturer of metal tie and spacer wishes to establish distributing points throughout the country.

Manufacturer of mechanical spreaders for cover material desires representation by organizations covering entire states. Several desirable states are still open. Number of inquiries now on hand for spreaders require immediate follow up.

Manufacturer of complete line of construction equipment, mixers, saw rigs, plaster and mortar mixers and pumps has an open territory in the state of Maine and is looking for an aggressive distributor to represent him there.

Long established and well-known manufacturer of industrial locomotives wishes to make contacts with qualified distributors. Locomotive line includes steam, gasoline, gas-electric and oil-electric. Supported by national trade journal advertising.

GOLDEN-ANDERSON

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Float Valves

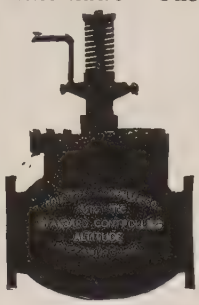
Adapted to automatically maintain a uniform water level in feed-water heaters, tanks, reservoirs, and pans. Very sensitive.

Operating on ½-in. to ¾-in. variation. No exhaust or expensive water waste. Can be furnished for hot or cold initial water supply. Reliable and dependable under varying pressure.

Sizes ½ in. to 24 in.

Automatic "Cushioned" Controlling Altitude Valves

Cushion All Water Surges



Automatically maintains a constant stage of water in reservoirs, tanks and standpipes. They do away with the annoyances of Freezing Valves and Float fixtures inside of the Tanks or Floats and Fixtures outside of Tanks. "Three Ways of Closing These Valves."

1st—Automatically, by water.
2nd—By electricity, if desired.
3rd—By Hand.

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe.

The double cushion effect of air and water eliminates water hammer. There are no dangerous surges to burst water mains. **Write for details.**

REMEMBER

Valves cushioned at all times by air and water. No water hammer or bursting mains.

"Made with stop starter attachment for centrifugal pumps."

Golden-Anderson Valve Specialty Co.

1385 Fulton Bldg., Pittsburgh, Pa.

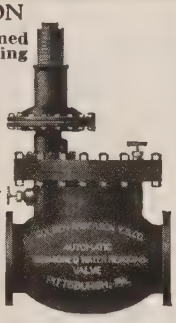
GOLDEN-ANDERSON

Patent Cushioned Water Relief Valves

1. Automatically relieve excess pressure.
2. Prevent stress, strain and bursting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and globe pattern. Sizes 3 to 24-in.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Pressure Regulating Valves



1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

GOLDEN-ANDERSON

Pat. Automatic Double Cushioned Check Valves

1. Especially adapted for Water Service.
2. For High or Low Pressure.
3. Thoroughly Cushioned. No Chattering, Hammering or Sticking.
4. Globe or Angle Patterns up to 24 in.
5. Especially adapted for hydraulic elevator service.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipe, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle—Most Satisfactory Float Valves known.
4. No Metal-to-Metal Seats—No Water Hammer or Shock.
5. Cushioned by Air and Water.

Sizes ½" to 24".

Modern... Efficient...

KING Sludge Bed Enclosures for Up-to-date Systems

Sanitary engineers the country over strenuously advocate glass enclosure for sludge beds. It offers a number of advantages indispensable to the up-to-date sewage system.

Continuous operation. King Sludge Bed Enclosures make possible all-weather sludge drying. Rain or shine, winter or summer, the sludge beds are ready regularly for sludge removal.

Greater capacity. By equipping the sludge bed with a King Enclosure, its capacity is increased between two and three times. Sludge may be run to a greater depth and dried more quickly.

Elimination of odors. Through control of odors, King Enclosures practically eliminate all offensiveness of sludge beds.

Attractive. King Enclosures are trim and neatly designed, vastly improving the appearance of the disposal plant.

Let us tell you more fully about this modern trend in sewage disposal. Write for descriptive folder on King Sludge Bed Enclosures.

KING CONSTRUCTION COMPANY

533 Wheatfield St., North Tonawanda, N. Y.

Gordon Huth Made Safety Director for Universal Atlas Cement Co.

Rising from a machinist's helper in 1915, when he was 19 years old, to safety director for the largest cement company in the world at 33, is the experience of Gordon Huth of Duluth who on February 10 was appointed safety director for the Universal Atlas Cement Company, a subsidiary of the United States Steel Corporation, according to an announcement by B. F. Affleck, president of that company.

Mr. Huth has been connected with the company for about 15 years, during 11 of which he has been safety inspector at Duluth. In his new position he will have his headquarters in Chicago.

Advance announcement of Mr. Huth's appointment was made on February 5 at the monthly safety meeting of the Industrial Safety Committee of the Duluth Chamber of Commerce of which he was chairman. At that time a message was read from Mr. Affleck congratulating Duluth on the progress it had made in industrial safety and announcing the appointment of Mr. Huth to his new position.

"In three different years," reported Mr. Affleck, "the Duluth plant has won safety trophies for operating a year without a disabling accident. In one of these years it was the only cement plant in the United States to do this. This year it celebrated two years' continuous operation without an accident. The same safety measures in force at Duluth have been followed at our other plants with the result that accidents have decreased 94 per cent in 10 years."

Max Berns Again Heads Advertising Council for C. A. C.

On Jan. 27, the Advertising Council of the Chicago Association of Commerce again elected Max A. Berns as chairman. Mr. Berns is active in the construction field, both in an engineering and advertising capacity, and is publicity manager of the Universal Atlas Cement Company, a subsidiary of the United States Steel Corporation.

The entire field of advertising is covered by the Council, and the officers and directors associated with Mr. Berns are publishers of Chicago daily newspapers, advertising managers of large Chicago manufacturers and retailers, agency executives, direct mail producers, typographers and other groups.

Mr. Berns' work in the engineering and construction field has identified him with movements for winter building, for fire-safe construction, for grade separations and for wider roads and streets. He is a member of the executive committee of the Chicago Association of Commerce and also of the general publicity committee of the association. He has also served as chairman of the contractors and building materials division of the association. He is a member of the advertising committee of the United States Steel Corporation and a director of the Chicago Better Business Bureau.

Max A. Berns, Chairman Advertising Council, Chicago Association of Commerce

For sixteen years Mr. Berns was associated with the Universal Portland Cement Company, with which the Atlas Portland Cement Company recently joined. He is a graduate of the College of Engineering, University of Illinois, and during the World War served as captain of Engineers, U. S. A. He is a member of the Chicago Engineers' Club, Western Society of Engineers, American Society of Civil Engineers, Society of American Military Engineers, Engineering Advertisers' Association, National Industrial Advertisers' Association and International Direct Mail Advertising Association.

Personnel Items from Bay City Shovels

Several personnel changes have been announced by Bay City Shovels, Inc., of Bay City, Michigan, regarding district sales managers for this company.

Mr. C. C. Johnson of Marion, Indiana, formerly connected with the Osgood Company, has been appointed district sales manager for Bay City Shovels in charge of Indiana and Ohio territory.

Mr. C. H. Collier has been appointed district sales manager in charge of sales in the entire state of Texas with offices in the Burt Building, Dallas.

Mr. R. D. Aldrich, formerly of Chicago, will be located at the factory office in Bay City as agency sales manager in charge of all distributors in the central district.

The Eastern Contractors Equipment Company, Frederick, Maryland, will act as exclusive distributors of Bay City for the state of Maryland.

Pomona Pump Company Appoints Argentine Representative

In order to service the Argentine, a distributor for Pomona Pumps has been appointed by The Pomona Pump Company. The David Hogg & Cia. is to represent this company in Buenos Aires.

Don Frederic Klein has been appointed to represent the same company in San Salvador, Central America. By reason of his engineering experience and installations carried out under his supervision, Mr. Klein is said to be well fitted for this new work.

Several Pomona Pumps have been shipped recently to Australia for municipal service near Nhill, Victoria. Bethune Brothers in Nhill are Pomona representatives.

Announcement

The firm of A. E. Moeller Company, manufacturers of hydrometers, barometers, thermometers and similar instruments, has been succeeded by the Moeller Instrument Company.

Announcement states that ownership and management will continue as in the past with the following personnel: Charles E. Moeller, president and general manager; Max E. Moeller, vice-president and head of research department; Curt F. Moeller, treasurer and factory manager; Paul G. Moeller, secretary and director of sales department; Otto J. Moeller, assistant treasurer and glass production department, and Walter G. Moeller, production department.

The Moeller Company is located at 261 Sumpter St., Brooklyn, New York.

Announcement

B. M. Hall, Jr., and Warren E. Hall will continue the consulting practice of B. M. Hall & Sons, civil and mining engineers, Atlanta, Ga. This firm was established in 1899 by Benjamin M. Hall who died November 19, 1929, after more than 50 years of active engineering work.

B. M. Hall, Jr., has been a member of the firm since 1916, while Warren E. Hall served as district engineer U. S. Geological Survey, Water Resources Branch from 1912 to 1924, since which time he has been engaged in private engineering work in North Carolina and Georgia.

Alan Wood Steel Company, Conshohocken, Pa., announces the transfer of Mr. Willard S. Haring from the eastern office to Los Angeles, Calif., as vice-president in charge of western sales.

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

The First Hundred Years

ACCEPTING the slogan that "the first hundred years are the hardest" Fairbanks, Morse & Company has successfully reached the top of the hill and may look back over the century with a just sense of pride in its achievements.

Distributor News is very grateful to them for being allowed to look over the proof pages of "The F-M News" and to be able to present to our readers so many interesting notes of the many changes which have taken place in this great organization during this century just completed and to show pictures from "way back when" up to the moment of going to press.

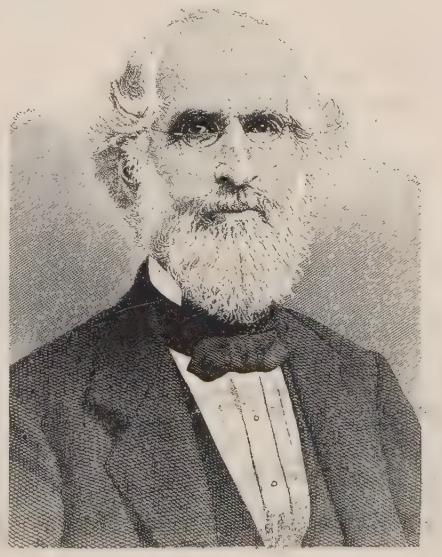
Old Homestead of the Fairbanks Family, Built in 1636, in Dedham, Mass., Is Still Standing

In presenting their story of "A Hundred Years of Fairbanks Scales" in the centennial number of their paper, they use as their lead-off the well known quotation from Emerson: "If a man preach a better sermon, write a better book, or build a better mouse trap than his neighbor, though he build his house in the woods, the world will make a beaten path to his door." And, in condensed form today we say: "Quality counts."

Although Thaddeus Fairbanks, born in 1796, is the first name associated with the company our story is concerned with, the family name goes back in the history of the country almost two hundred years previous to that date, for in 1636 Jonathan Fairbanks built the old homestead in Dedham, Mass., and the old house is still standing as a monument to the enterprise of our first settlers.

The parents of Thaddeus Fairbanks, however, left the established centers of civilization and joined a general movement toward the frontier, which took them, in 1815, to St. Johnsbury, Vt., where for $300 Major Joseph Fairbanks purchased five acres of land with falls rights on Sleepy River. Here Thaddeus, after helping with the building of his father's house, as well as the grist mill and saw mill, began the erection of a mill for the manufacture of wagons, the young Fairbanks first business venture. In 1823, with the wagon business going nicely, Thaddeus opened a small iron foundry, and a year later the business of the mills had grown to such proportions that his older brother, Erastus, gave up the country store he was running to become a partner of his brother. Under the firm name of E. & T. Fairbanks these two young men began the manufacture of wagons, plows and stoves.

In April, 1826, Thaddeus filed his first application for a patent, which was for the exclusive right to manufacture and market cast iron plows, the first of the kind that had, up to that time, been used. While the farmers were slow to use them, declaring that they would soon break to pieces and that further they poisoned the soil, the business grew until now all the world uses them. The business prospered beyond the expectations of either of them, and in 1828 the brothers decided to concentrate their efforts and accordingly disposed of the wagon works and stock at a public sale.



Thaddeus Fairbanks

The active and imaginative brain of Thaddeus was already at work, for about this time he is credited with having invented what was known as the diving flue stove, an important development to improve combustion control, as well as the principle of cooling now generally employed in refrigerators. He secured a patent for this latter, but as he had neither the time nor the money to develop it, he gave it away. In later years the rights in this patent were valued at $1,000,000.

About the years 1829-30 a boom struck Vermont in the form of a craze for raising hemp. E. & T. Fairbanks built several hemp dressing machines and Thaddeus patented an improved dresser and became manager of the St. Johnsbury Hemp Company. The weighing apparatus then used was the old Roman steelyard, suspended in a gallows frame, which left much to be desired, both as to accuracy and ease of operation. So, again the inventive genius of Thaddeus Fairbanks worked out a platform scale, which served the need for which it was produced, but upon which the inventor placed little value, thinking the demand for it would be too limited. But when order after order came for these scales, Erastus saw the possibilities for the use of the new invention.

First came the idea of supporting a platform upon an "A" shaped lever in such a way that the top of the lever could be connected to the steelyard by a rod, then came the idea of two "A"-shaped levers, or with four

straight levers meeting at the steelyard rod, and after working out these plans to his own satisfaction, Thaddeus Fairbanks set out on horseback for Washington to file his patent claims.

This was in the year 1831, the year in which the sewing machine was invented and the year of the first railroad in America, operated by the B. & O. R. R. Many important developments are recorded just prior and immediately following this time, which saw the opening of the Erie Canal, the invention of the friction match, the first successful steam locomotive, the McCormick reaper, the Morse telegraph code and the Daguerreotype. Comments of Mr. Fairbanks concerning his working conditions make interesting reading in these days of up-to-the-minute machine shops: "My plans were all made in the night, frequently working nearly all night on them. For lack of tools the scale work all had to be finished by hand and this, with work on patterns, etc., required all my time during the day in the shops. Faulty work was sure to be sent out unless I was watching all the time; men had to be educated for the simplest operations. There was no uniform machine work as now and it was fifteen years before we had a planer in the shop. Our casting was done in a shed annexed to the old forge, and although we were still in want of funds a larger building was finally put up. It devolved on me to put in the cupola and fixtures, blast, etc., and start operations. I moulded and took the melting often, as there was no other way to learn what caused the unsound stogy places and air blisters that occasionally occurred. In order to teach the men how to make sound castings I had to work several months mixing metals and testing their composition. In making the plans for scales I found there were three things to be considered—the strength of materials, the best shape to secure greatest strength with least material, and the beauty and symmetry of the outside appearance. To imagine what the tastes and notions of men in reference to the right proportioning and beauty of this, then new, article would be, was difficult, but now after fifty years our platform scales are made along the same general design."

If space would permit we should like to tell here the fascinating story of the development of weights and measures from the time of the ancients to the time when the invention of Thaddeus Fairbanks revolutionized these ancient processes and laid the foundation for the scale business of the present day. But this is the story of Fairbanks, Morse & Company, and we have just begun. With the invention of the platform scale the whole attention of Thaddeus and his brothers was concentrated on the development of this business.

The original shop in which the scales were first made was a wooden building 25x60 ft.; it was the factory, warehouse and salesroom combined. The capital invested was $4,000, and there were only ten men on the pay roll. Joseph Fairbanks gave up his law practice to join his brothers and the firm name of E. & T. Fairbanks & Company was adopted. For thirty years Erastus served as business head of the firm and for fifty-five years Thaddeus kept busy drawing plans, designing new scales or modifications and inventing machines for making parts. Joseph was with the firm twenty-two years, and the three brothers were the first salesmen. Most of the correspondence of the early years has been preserved and tells a story of business methods of the times, of scales being rented and also sold on the installment plan, although not called by that name. One conscientious salesman writing from Rio de Janeiro submitted the following: "I am obliged to purchase a dress suit costing $24 on purpose to wear at my audience with the Emperor. I shall probably never wear it again. Shall I add this suit to the bill?"

The Birthplace of the Modern Scale—The Fairbanks Scale Works in 1830

Beside the well established trade in the United States and Canada, the English market was opened in 1835, and trade with China was established in 1846. The story now becomes one of trade expansion and meritorious awards, including foreign decorations conferred upon Thaddeus Fairbanks.

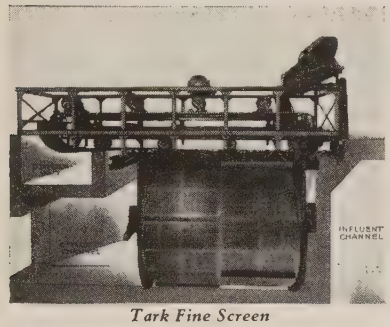
At the time of the Civil War Erastus Fairbanks was governor of Vermont, and many artillery and cavalry supplies were turned out by the factory. The New York branch officials aided Governor Fairbanks in securing requirements for the cavalry and infantry regiments of Vermont. Although the St. Johnsbury plant has always been the largest factory devoting its energies to the making of scales, other products have been added, and electric dynamos were being made and contracts filled for lighting manufacturing plants as early as 1886.

The company was incorporated in 1874, but from the beginning, with its establishment by the three brothers, Fairbanks' sons and grandsons took

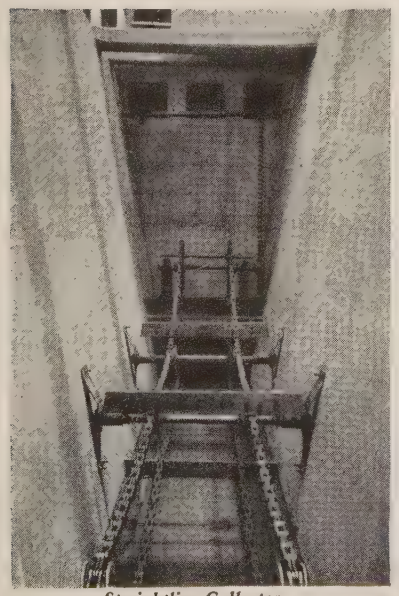
The Plant on the Hill—The Williams Engine Works and The Eclipse Wind Engine Co.—1889

LINK-BELT Equipment for Sewage Treatment Plants

Brunotte Bar Screen



Tark Fine Screen



Straightline Collector

ENGINEERS and operating men have learned, through practical contacts, that Link-Belt equipment is built to high practical ideals, and with the purpose of giving the customer a little more than he expects

Ruggedness of construction, coupled with fineness of design are outstanding features of Link-Belt Screens, Collectors and Aerators. Their efficiency in the removal of suspended solids, and a minimum of required attendance, are other factors appreciated by engineers.

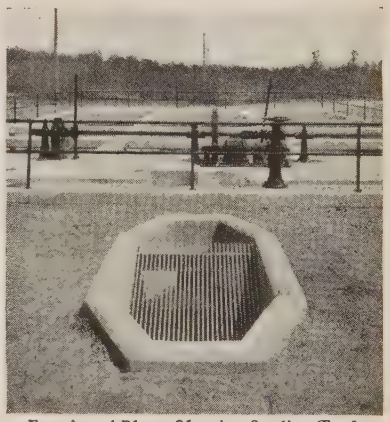
The experience of Link-Belt engineers is offered freely to those who are considering the subject of sewage disposal.

We do not undertake to lay out complete sewage disposal plants . . . this is the function of the consulting or sanitary engineer . . . but we are always glad to assist in formulating plans for the most efficient use of such apparatus as we manufacture for sewage plants.

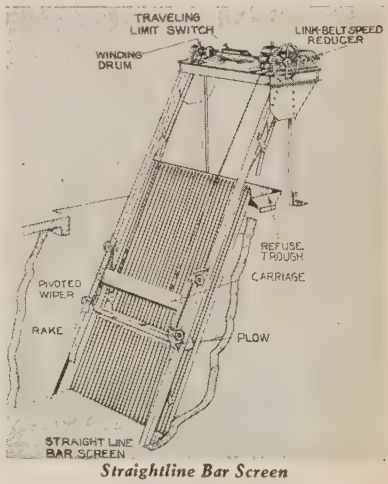
Send for Our New Book No. 642

LINK-BELT COMPANY
Leading Manufacturers of Materials Handling and Power Transmission Machinery and Chains
CHICAGO, 300 W. Pershing Rd.
PHILADELPHIA, 2045 W. Hunting Park Ave.

Mechanical Aerator



Exterior of Plant, Showing Settling Tanks



Straightline Bar Screen

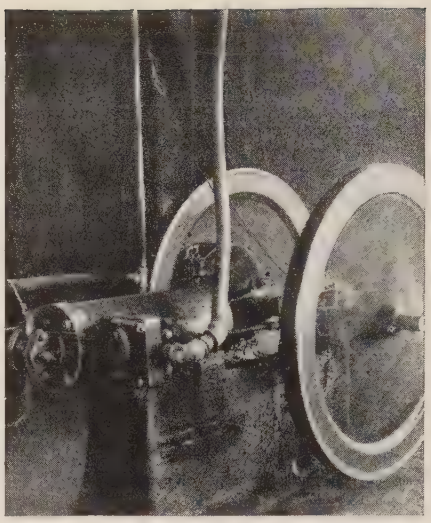
3879

LINK-BELT

Sewage Treatment Plant Equipment

their places in important positions in the business management, expansion and distribution of the factory products. Franklin Fairbanks, one of the third generation, also had a mechanical bent and many of his inventions were patented. This member of the family had many and varied interests. He was a member of the Vermont legislature, and was active in raising and equipping the first five Vermont regiments during the Civil War. He was a director in several mining companies, and also one of the directors of the Maritime Canal Company of Nicaragua. He was a trustee of Northfield Seminary, Rollins College at Winter Park, Florida, and the Soldiers' Home at Bennington. He gave to his home town the Fairbanks Museum of Natural Sicence. This interest in educational benefactions was another trait in common with Thaddeus Fairbanks, who for twenty years assumed the support of the St. Johnsbury Academy, which the three Fairbanks brothers had founded in 1842. This is the academy, by the way, where ex-President Coolidge received a part of his education. Thaddeus Fairbanks' only son, Henry, also was an inventor, having to his credit some twenty-five patents. The grandson of Thaddeus, Robert Fairbanks, entered the Chicago branch of the company after graduating from college and later became manager of the London house.

As early as 1870 a noted English writer characterized the town of St. Johnsbury as a "workingman's paradise." Some of the reasons for this expression may be found in a quotation from the "American Centenary" in 1876, in writing of the firm of E. & T. Fairbanks & Company: "These men have always displayed the most generous and judicious spirit of liberality and kindness towards those whom they employ, providing means for their mental, moral, religious and esthetic culture, in a way that makes their establishment a model one. They have provided for scientific lectures; created a lyceum; established free schools; a free library and reading-room; and a free art gallery with suitable buildings for



One of the Earliest Gasoline Engines, Fairbanks-Charter Engine Installed in 1898 is Still Running

all. * * * There is not, probably on the face of the earth, a community of working people who enjoy so much solid comfort as these. The proprietors and workmen regard each other as mutual friends."

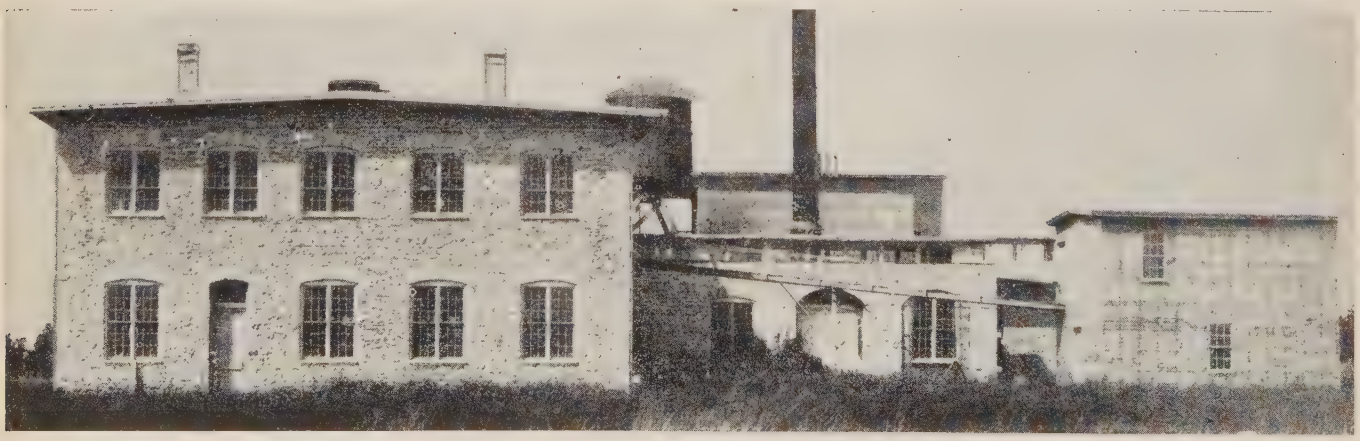
To refer once more to the expression used at the beginning of this story "quality counts," possibly it would be better to change it to "accuracy counts," for the chief concern of every one connected with the St. Johnsbury plant is for accuracy, the whole prestige of the scale being based on this one characteristic.

Up to this point in the story the only firm name referred to has been the E. & T. Fairbanks Company, but the history of this organization is really divided into two phases, the E. & T. Fairbanks & Company phase and the Fairbanks, Morse & Company phase, the first centering around Thaddeus Fairbanks and his inventions and the second around the life of Charles Hosmer Morse, who became a part of the history of this company when he went to work for it in St. Johnsbury at the age of seventeen, having been born there three years after the invention of the scale. This seventeen year old boy apprenticed himself to the company for three years at $50 a year. Later as an advancement he was sent to New York where, according to the story, soon after his arrival he sat down on a curbstone and fought a battle of homesickness, pondering whether to turn back or go on. He did not turn back then nor thereafter.

He entered the St. Johnsbury factory in 1850. In 1857 he was transferred from New York to the Chicago office, and in 1865 he went to Cincinnati to establish the first branch of the business to be known as Fairbanks, Morse & Company. A second house under the same name was opened the same year in Cleveland, and then followed offices at Pittsburgh and Indianapolis, although the Pittsburgh office was later transferred to the Fairbanks Company.

Up until 1870 the Chicago branch of the business was known as Fairbanks, Greenleaf & Company, but owing to the failing health of Mr. Greenleaf, Mr. Morse was called to the Chicago office and was admitted into partnership of this company. At the time of the Chicago fire the store was located on State St. near Madison St., and with other business houses was entirely burned out. The partially charred records of the company were taken from the cellar of the building and by careful handling and the aid of loyal customers accounts were made out and settlements made, and the firm of Fairbanks, Greenleaf & Company, as such, ceased to exist. The Chicago fire started on Sunday night, continuing until after nightfall Monday. On Tuesday morning a small store and basement on Canal St., untouched by the flames, was opened for business as Fairbanks, Morse & Company. Here with kitchen tables and chairs for office furniture and more orders than goods, anxious customers were cared for. As soon as new quarters were available Fairbanks, Morse & Company moved to Washington St., and then followed one or two other moves, until the year 1908, when they located in their present offices at 900 S. Wabash Ave.

With the transfer of Mr. Morse to Cincinnati to serve territories sparsely



The Beloit Wagon Works in 1880, the Foundation of the Present Beloit Plant

"Caterpillar" Tractors serve growing cities in endless ways. Here is a new airport being built on waste tidelands. Right to the edge of the quicksand the "Caterpillar" rides confidently. Wide, long tracks laugh at mud and sand. Later this same nimble power plant may be used to carve out municipal golf courses, to smooth bumpy streets, to clear away drifted snow—to win the approval of taxpayers in a score of ways!

Changing the face of nature

Prices—f. o. b. Peoria, Illinois

TEN	$1100	TWENTY	$1900
FIFTEEN	$1450	THIRTY	$2375
	SIXTY	$4175	

Caterpillar Tractor Co.

PEORIA, ILLINOIS *and* SAN LEANDRO, CALIF., U. S. A.
Track-type Tractors / Combines / Road Machinery
(There's a "Caterpillar" Dealer Near You)

CATERPILLAR
REG. U. S. PAT. OFF.
TRACTOR

settled, he cast about for other lines to sell in order to keep down the overhead necessary to maintain an efficient sales force. He opened a factory in Cincinnati in 1866 for the manufacture of letter and waybill presses and warehouse trucks. Just about this time the Reverend Leonard H. Wheeler brought out the first hinged vane windmill. Dr. Wheeler had an Indian mission in Wisconsin which he moved from Ashland to Beloit in 1867, and on the advice of friends took out patents on his windmill. Here with his sons he conducted a rapidly growing business in windmills. In 1880 Mr. Morse secured the sales agency for this product and this formed the first step in the association from which has grown the large Beloit plant of Fairbanks, Morse & Company. When the windmill company was incorporated in 1881 as the Eclipse Wind Engine Company, Mr. Morse secured an interest in the business for Fairbanks, Morse & Company.

The business at the Beloit plant proved so profitable that more space was needed for manufacturing and the Eclipse Wind Engine Company bought the plant "on the hill," then known as the Beloit Wagon Works, and the site of the present factory. It was in this first plant that Fairbanks, Morse & Company began their association with the engine business. Mr. W. H. Wheeler, president of the Eclipse Wind Engine Company, and a son of old Dr. Leonard, the windmill inventor, together with Mr. Morse and Mr. E. F. Williams, formed a corporation known as the Williams Engine Works, to promote the sale of a steam engine with which Mr. Williams had been experimenting. The citizens of Beloit, realizing the advantages of retaining a manufacturing establishment of this kind, donated $10,000 and ten acres of land to the new company, thus bringing the total acreage of the two companies up to forty-one.

The lines developed at Beloit included windmills, tanks, pumps and hoisting engines, and when the Chicago Arc Light & Power Company, in 1890, installed in their plant three 500-hp. tandem compound engines, these were

C. H. Morse.

the Williams engines made at Beloit. All the transmission equipment was furnished at that time by the Eclipse Wind Engine Company. This large Chicago company came under the management of Samuel Insull in 1892, which soon became the Chicago Edison Company, and later the Commonwealth Edison Company. While Fairbanks, Morse & Company had been selling pumps for sometime, they were first made in the Beloit plant, when a line of steam pumps was brought out in 1891. Later several other types, including the gear-driven and centrifugal pumps, were added, making the line quite complete.

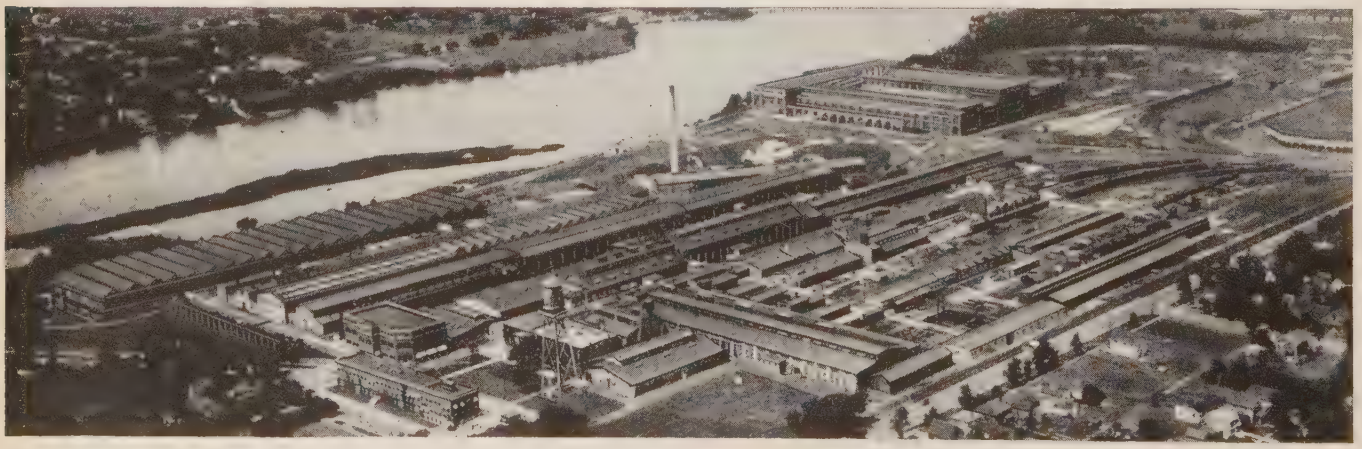
The agency for hand cars of the Sheffield Velocipede Car Company of Three Rivers, Mich., was taken over by Fairbanks, Morse & Company in 1883, and by 1895 experiments were being conducted to perfect a light gasoline engine to be attached to the three-wheeled car, in order to secure a self-propelled type of car, which at that time had never been built. This led to other railroad products, including standpipes, water towers and tanks, coaling stations and always scales, a line with which Mr. Morse never lost close contact.

The Deisel engine business of the company was started about 1893, when Mr. Morse engaged the services of James A. Charter, who had brought his drawings and patterns of gasoline engines to the Beloit plant. He had been associated with his father, John Charter, for some time in the development of the gasoline engine, and their first patent on this type of prime mover is dated Sept. 12, 1887. The first engines built at Beloit were of the four-cycle type, and in 1895 the first small vertical engine appeared. From this time on followed a period of rapid development in motive power, up to the present-day line of ball bearing motors, another field in which Fairbanks, Morse & Company pioneered.

Development of a line of pumps was started in the late '70s, beginning with the Eclipse double acting, vertical cylinder force pumps which were used with the Eclipse windmill. Pumps of various design were built as the demands arose. These included the direct acting steam pump, the geared design, centrifugal pumps and the Wood trash pump and Price deep well pump.

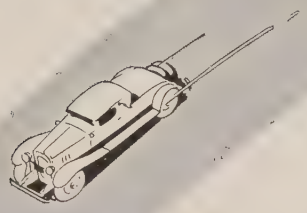
At this time the plant at Three Rivers, Mich., handles the output of Sheffield cars, wind mills, pumps and railroad equipment. Beloit is devoted to the gas and oil engines, including the generator for the Deisel electric sets and the new line of synchronous motors which are closely allied with the generator. The Indianapolis plant is devoted exclusively to the manufacture of electric motors, and scales continue to be made in St. Johnsbury and East Moline, Ill.

As territory after territory was opened up in the pioneer days, Mr. Morse established branch after branch for his great company, until there are now thirty-one branch offices in the United States alone. The Canadian Co. was established in 1908 at Sherbrooke, on property donated to the E. & T. Fairbanks Company. The Canadian



The Beloit Works of Fairbanks, Morse & Co. as It Appears Today

IMPROVE YOUR OLD ROADS



Save Money on Construction and Upkeep

Dirt roads and gravel roads can be made into year 'round, farm-to-market highways with various treatments combining mineral aggregate with asphalt road oil or cut back asphalt.

Such roads are possible with a small appropriation. The present surfacing is not discarded, but is used as a base. The county already has the equipment to do the work. This work requires little labor, as most of it is done by machinery.

These roads are durable. The material is not blown away, but is conserved — it is left on the ground. The road is made better through use.

Thousands of miles of roads in hundreds of counties in the Middle West have been improved with the above treatments, and given complete satisfaction. Because of their low cost, durability and economy of maintenance, such improved roads can be had in your county—this year.

Mail the coupon below for specifications and full information.

Minnesota State Highway. Treatment of subgrade with Standard Asphalt Road Oil. Note smooth, dustless surface which is in good condition throughout the year.

South Dakota Highway. Three inches of gravel being treated with Standard Asphalt Road Oil by the mixed-in-place method. This method insures a durable, year'round riding surface.

Linn County, Iowa, September, 1929. Stanolind Cut Back Asphalt retread just after the keystone has been applied. This method of road improvement is an economical way of salvaging your old road bases.

Four proven road treatments, one of which will fit into your road surfacing program

Preparing Sub-grade with Standard Asphalt Road Oil prior to the application of gravel. When subgrades are treated by this method and covered with 350 cubic yards of gravel per mile, the asphalt road oil does two important things: it holds the gravel in place, and waterproofs the subgrade.

Mixed-on-the-Road Method. An untreated gravel road carrying 500 cars a day loses approximately an inch of surface a year through dust, which is costly waste. You can treat three inches of this gravel by the mixed-in-place method as cheaply as you can maintain the gravel road. When Standard Asphalt Road Oil is specified, the surface obtained will be hard and smooth the year 'round.

Surface Treating of Hard Surfaced Roads, such as compacted gravel, crushed rock and other hard surfaces, with Stanolind Cut Back Asphalt is an economical way of maintaining these roads. It entirely eliminates dust and cutting up in bad weather.

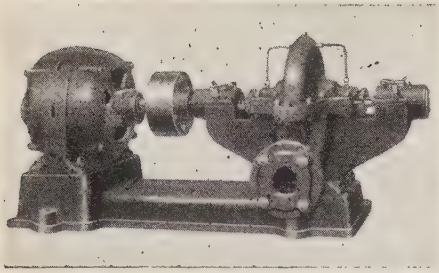
Stanolind Cut Back Asphalt Retread (or mixed-in-place method) is a practical method for building a wearing surface on present road bases. This type of road is easily and quickly constructed. It is non-skid and durable. The cost comes within that of building standard low cost improved roads.

Standard Oil Company
(Indiana) 226

Standard Oil Company *(Indiana)*, Room 1219
910 South Michigan Avenue, Chicago, Illinois
You may send me specifications and plans for improving secondary roads with Asphalt Road Oil and Cut Back Asphalt.

Name .....
Address .....
City ..... State .....

Asphalt and Road Oil for Low Cost Improved Roads



Centrifugal Pump and Direct Connected Motor Products of the Three Rivers and the Indianapolis Paints

company is now called the Fairbanks, Morse Co., Ltd.

Mr. Morse was visionary yet practical, thrifty but generous, conservative but progressive, and his policy of always maintaining sufficient capital at hand to take advantage of any sales possibilities was responsible for many of his most successful developments. On his death, in 1921, his son, C. H. Morse, became president of the company, a position he held until his election to the chairman of the board of directors. At that time R. H. Morse was made vice-president of the board of directors and W. S. Hovey was elected president of the company.

Mr. Hovey, who was born in 1875 and is a graduate of Cornell, joined the Sheffield Car Company in 1902, as assistant superintendent. In 1913 he was transferred to the Beloit works as manager of the engine division. In a few months following his transfer he was made general manager of the plant. In 1919 he was elected vice-president in charge of all manufacturing activities, and 1924 was made general manager of the entire business.

Due to the high type of products and efficient marketing organization this company now does an annual business in excess of thirty-three million dollars, and the original investment in the scale business in 1830 was $4,000.

Dr. James Aston Awarded Robert W. Hunt Medal

At the annual dinner of the American Institute of Mining and Metullurgical Engineers, held recently in New York City, the Robert W. Hunt medal was conferred upon Dr. James Aston, director of mining and metallurgy at the Carnegie Institute of Technology, in recognition of his paper on "A New Development in Wrought Iron Manufacture."

Dr. Aston is consulting metallurgist of the A. M. Byers Company of Pittsburgh, and his method for quantity production of wrought iron is known commercially as Byers' New Process, because of its adoption by that company, which is now building a $10,000,000 plant for its utilization just below Ambridge, Pa.

The paper deals with two years of observation and experience in the commercial production of the new process wrought iron at the Byers' plant at Warren, O. Its emphasis is placed on the practical rather than the theoretical phase of the process.

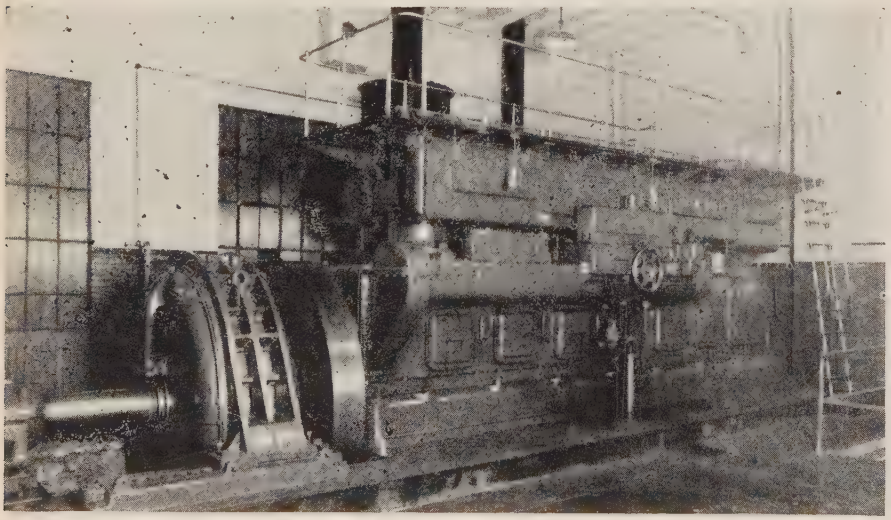
"The process," writes Dr. Aston, "is divisible into several steps, which correspond to and parallel the major subdivisions of the hand puddling method."

Dr. Aston presented the various steps of the process covering, melting, refining, disintegration of the metallic mass, the pouring and intermingling of the spongy mass of metal with liquid slag, etc. Many investigators, Dr. Aston states, including the Bureau of Standards and other government as well as marine and railroad representatives have found that the material conforms to all standards set for wrought iron, chemical, metallographic and physical.

"There is a benefit in the added work put upon the larger mass," Dr. Ashton says, "uniformly low content of carbon in the blown metal has resulted in virtual elimination of blisters, the bane of wrought iron manufacture. Low metalloid content, and particularly the controllability and adjustability of metal and slag character independently, has benefited the welding and other physical properties of the product. In addition, this operating advantage points the way to the manufacture of wrought iron of special characteristics and adaptibility, including the possibility of entry into the alloy field.

The paper concluded with an outline of the new plant being built for the A. M. Byers Company, where the balls will be about two tons in weight. He says: "A more rapid operation will be obtained by a cup-car system of handling, with progressive movement of the cars to the several zones. Initial production will be 600 gross tons per day, with only minor extensions to double or treble this output. Immediate mill equipment will be blooming, plate, bar and skelp mills; with projected extensions to include blast furnace and coke oven plant and finishing mills.

In concluding Dr. Aston states: "This project should put wrought iron into proper place in the field of ferrous products, through an expanding market made possible by lowered costs, greater tonnages and diversification of output."



One of the Latest Fairbanks-Morse Diesel Generating Units Installed in a Semi-Isolated Public Utility Power Plant

House Magazines*

Editor's Note: This column is published every now and then. Many most attractive and interesting house magazines come to our desk from time to time, and we take this method of acknowledging them.

Sauerman News in the February issue carried a very interesting story of the new plant of the Beyrer Bros. Sand & Gravel Company at Mishawaka, Ind. This booklet is always so well illustrated and contains so many items on the uses of scrapers and cableways that any one with excavating and material handling problems would find it of great interest.

The U. S. Piper, now in its third volume, continues to be a most attractive quarterly on cast iron pipe and its applications. The March issue has a very interesting story on the Albany Water Supply, starting back with the service this city enjoyed from Revolutionary times, and containing many historical points of interest. The Piper is published by the U. S. Pipe & Foundry Company of Burlington, N. J., and edited by Ralph M. Shaw, Jr.

The Power Specialist is the monthly paper of Johns-Manville Company of New York City. A brief editorial on "The Worker, Give Him a Chance to Use His Mind" contains a constructive idea for all manufacturers who have not already made use of the Suggestion Committee Plan. Insulation problems, engineering innovations, corrosion troubles and questions of distribution are all touched upon in the February issue.

*Manufacturers named will be pleased to send above mentioned publications to readers upon request.

THE MOST IMPORTANT INGREDIENT IN YOUR PIPE COATINGS IS

EXPERIENCE

The best solution to any of the problems that come up in the business of coating pipes is knowledge. Robertson has the knowledge. The H. H. Robertson Co. is the world's largest producer of special asphalts. It has made investigations in the action of soils on coating materials. It can determine the exact combination of asphaltic bases that are best calculated to protect your pipe under any given set of conditions . . . and it can produce exactly that combination.

Specify Robertson coatings on your pipes.

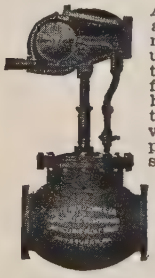
H. H. ROBERTSON CO.,
PITTSBURGH, PA.

ROBERTSON HAS THE EXPERIENCE

GOLDEN-ANDERSON

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Float Valves



Adapted to automatically maintain a uniform water level in feed-water heaters, tanks, reservoirs, and pans. Very sensitive.

Operating on ½-in. to ¾-in. variation. No exhaust or expensive water waste. Can be furnished for hot or cold initial water supply. Reliable and dependable under varying pressure.

Sizes ½ in. to 24 in.

Automatic "Cushioned" Controlling Altitude Valves

Cushion All Water Surges

Automatically maintains a constant stage of water in reservoirs, tanks and standpipes. They do away with the annoyances of Freezing Valves and Float fixtures inside of the Tanks or Floats and Fixtures outside of Tanks. "Three Ways of Closing These Valves."

1st—Automatically, by water.
2nd—By electricity, if desired.
3rd—By Hand.

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe.

The double cushion effect of air and water eliminates water hammer. There are no dangerous surges to burst water mains. **Write for details.**

REMEMBER Valves cushioned at all times by air and water. No water hammer or bursting mains.

"Made with stop starter attachment for centrifugal pumps."

Golden-Anderson Valve Specialty Co.

1385 Fulton Bldg., Pittsburgh, Pa.

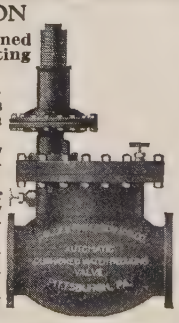
GOLDEN-ANDERSON

Patent Cushioned Water Relief Valves

1. Automatically relieve excess pressure.
2. Prevent stress, strain and bursting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and globe pattern. Sizes 3 to 24-in.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Pressure Regulating Valves



1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

GOLDEN-ANDERSON

Pat. Automatic Double Cushioned Check Valves

1. Especially adapted for Water Service.
2. For High or Low Pressure.
3. Thoroughly Cushioned. No Chattering, Hammering or Sticking.
4. Globe or Angle Patterns up to 24 in.
5. Especially adapted for hydraulic elevator service.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipe, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle—Most Satisfactory Float Valves known.
4. No Metal-to-Metal Seats—No Water Hammer or Shock.
5. Cushioned by Air and Water.

Sizes ½" to 24".

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Distributor thoroughly familiar with bituminous materials and equipment for handling, wishes to add to present lines. Covers Wisconsin and Illinois territory.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Distributor covering New Jersey and New York territory would like to secure a line of street markers or other traffic equipment on exclusive basis.

Equipment distributor in Pacific Northwest desires line of road building equipment, structural building equipment, dump bodies and truck hoists.

Distributors of contractors' and builders' machinery and equipment are seeking line of road forms, road finishers, batcher plants, clamshell buckets and drag line buckets, for northern California terirtory. Now stocking equipment for several well known machinery manufacturers.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Road machinery distributor would like to secure exclusive sales rights for state of Mississippi for line of automatic or self-loading wheeled scraper.

A Michigan distributor, with many years' experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing increased facilities in this region.

Equipment distributor located in Michigan desires to add two or three good lines to serve territory in southeastern part of state.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Distributor of building specialties covering a territory of 100 mile radius from Chicago is equipped to represent additional lines.

Machinery distributor established in Porto Rico and Santo Domingo would be pleased to make arrangements to take on new lines in these territories.

Machinery company in the east is interested in representing established lines of road machinery, with the exception of graders.

Representatives Wanted

Manufacturer of cut to length, easily erected standardized steel highway bridges, for spans up to and including 40 feet, which are sold to highway commissioners and superintendents, has attractive territory open in states south and west of Chicago.

Manufacturer of Transverse Testing Machines desires to build up distribution organization in this country and abroad.

Manufacturer of plows, grade-rippers and scrapers desires representation in Arizona, New Mexico, Arkansas, Kansas and Louisiana.

One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

Manufacturer of paving expansion joints is seeking distributors and manufacturers' agents in good, unassigned territory.

Manufacturer of air compressors and contractors tools has number of desirable territories open. Full co-operation will be extended to distributors.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of hoisting machinery and air compressors has open territory in New York and New England states for aggressive distributor.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Attractive territory available for experienced men to handle contractors' labor-saving equipment by old established company. Equipment backed by national advertising.

A manufacturer of paving expansion joints is looking for distributors for northern California territory.

Manufacturer of metal lath, corner beads, channels and reinforcing mesh desires to secure distributors for products in the southwest and middlewest.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Manufacturer of metal tie and spacer wishes to establish distributing points throughout the country.

Manufacturer of mechanical spreaders for cover material desires representation by organizations covering entire states. Several desirable states are still open. Number of inquiries now on hand for spreaders require immediate follow up.

Manufacturer of complete line of construction equipment, mixers, saw rigs, plaster and mortar mixers and pumps has an open territory in the state of Maine and is looking for an aggressive distributor to represent him there.

Long established and well-known manufacturer of industrial locomotives wishes to make contacts with qualified distributors. Locomotive line includes steam, gasoline, gas-electric and oil-electric. Supported by national trade journal advertising.

POMONA
Oceans of Water
PUMPS

Cleanest WATER FOR EVERY NEED . . .

Ample quantities of clean water produced for any desired purpose. Greatest pumping economy permanently maintained. The Pomona Water-Lubricated Turbine Pump is the ultimate in pumping equipment, designed for modern needs. The pump is entirely water lubricated below the surface of the ground. Impellers are of the open bottom type permitting variation of pumping capacity by means of an adjusting nut mounted on the top of the motor at the surface. Capacities up to 5000 gallons per minute furnished for all sizes of drilled wells or for sump service. Let our engineering department furnish you with complete specifications to meet your pumping needs. Write for bulletins fully describing this modern pumping method.

Write for name of nearest distributor or factory representative located in all principal cities.

POMONA PUMP CO.
Pomona, California

PERMANENTLY DEPENDABLE

Outgrown Sewerage Disposal
—made adequate by KING

King Glass-Enclosures for Sludge Beds Increase Plant Efficiency 3 Times

King Sludge Bed Enclosures offer a practical solution for the problem facing so many communities; outgrown sewerage disposal. For by trebling the capacity of the present sludge beds through year-round operation, these enclosures make it possible to accommodate three times the present population. No need to enlarge the plant, or increase the area.

There are many other advantages. King Enclosures, appealing in design, revolutionize the appearance of disposal plants, making them attractive and welcome in almost any community. And by means of controlled ventilation, the objectional odors (so common to sludge drying) are practically eliminated.

Let us tell you all the facts about the efficient service and sturdy construction of King Enclosures.

KING CONSTRUCTION COMPANY

533 Wheatfield Street
North Tonawanda, N. Y.

New York City · Philadelphia, Pa. · Boston, Mass.
Scranton, Pa. · Toledo, Ohio
Schenectady, N. Y. · Bridgeport, Conn.

Leonard W. Saine Succeeds Robert W. Conrow

Leonard W. Saine

The Central Foundry Company announces the appointment of Mr. Leonard W. Saine as General Manager of Sales for Universal Pipe Division.

Mr. Saine, who was the Company's representative in the South for a number of years, succeeds Mr. Robert W. Conrow. Mr. Saine will make his headquarters at the general offices of The Central Foundry Company, Graybar Building, Lexington Ave. and 43d St., New York.

A. M. Byers Increases Sales Force

Mr. L. M. Johnston, vice-president of the A. M. Byers Company of Pittsburgh, announces that in order to meet the growing demand for wrought iron piping it has been necessary to increase the personnel of the Byers sales organization. Mr. Johnston announces the following appointments:

D. S. Sampson assigned to the New York office, under Division Manager G. W. Hamill, to cover New Jersey territory.

R. C. Hamlett assigned to New Orleans, under jurisdiction of Division Manager A. D. Sheere of Atlanta.

Irwin P. Young, with headquarters in Chicago, under Division Manager M. G. Henderson.

T. D. Graham to St. Louis territory, under Chicago Division Manager M. G. Henderson.

About the Cement Institute

The Cement Institute is an association of manufacturers of Portland Cement, with general offices at 11 East 44th St., New York, N. Y.

The Purposes of the Institute, as set forth in the Articles of the Association, are as follows:

To promote the best interests of the cement industry by providing facilities for collecting, through voluntary action, information with respect to trade and commerce therein, and disseminating such information among the members of the Institute and the public generally. The information, so collected and disseminated, shall be as follows:

(a) Information concerning credits.

(b) Information concerning actually closed specific job contracts and other contracts for the future delivery of Portland Cement.

(c) Information concerning production and stocks on hand of clinker and Portland Cement and shipments of Portland Cement, and cloth sack returns.

To collect and disseminate such other and further trade information as the Institute may determine upon from time to time in accordance with the provisions of these Articles of Association.

To adopt and promulgate a Code of Ethics for the government of the members.

To establish and maintain all such lawful trade customs and usages for the protection of the members as the Institute may deem advisable.

To adopt lawful plans for the general development and improvement of the industry.

Any person, firm or corporation regularly engaged in the manufacture and sale of Portland Cement is eligible to membership.

The officers of the Institute are:

President—Blaine S. Smith, President Pennsylvania-Dixie Cement Corp.

Vice President and Treasurer—Morris Kind, President Hercules Cement Corp.

Vice President—M. C. Monday, President Hermitage Portland Cement Co.

Vice President—Chas. Irvin, Vice President Alpha Portland Cement.

Vice President—J. A. Lehaney, Vice President and Manager Lone Star Cement Company (Kansas).

The above officers, together with the following, are members of the Board of Trustees:

G. S. Brown, President of the Alpha Portland Cement Company.

George F. Coffin, Treas. and Gen. Mgr. Nazareth Cement Co.

Charles Schmutz, Vice President Bessemer Cement Corporation.

Col. E. M. Young, President Lehigh Portland Cement Company.

In addition to this New York office, the Institute has offices at present in Chicago, Illinois, and Kansas City, Missouri.

Col. Wm. J. Donovan is counsel for the Institute.

Luther G. McConnell is General Manager of the Institute.

George H. Reiter is Manager of the Chicago Division and Baxter D. McClain is Manager of the Kansas City Division.

Du Pont Technical Division Holds Annual Meeting

The 14th annual meeting of the Technical Section of the Explosives Department, E. I. du Pont de Nemours & Company, was held recently in the du Pont-Biltmore Hotel, Wilmington, Del. Arthur LaMotte, manager of the section, presided. More than one hundred subjects relating to explosives and their uses in mining, construction and for other industrial purposes were discussed by the eighty du Pont executives and field representatives from all parts of the United States.

J. W. McCoy, general manager of the Explosives Department, addressed the opening session, while L. P. Mahony, director of sales, was the principal speaker at the dinner which followed the close of the three-day meeting.

Edward R. Bacon Company Resumes with Byers Lines

The Byers Machine Company, Ravenna, O., announces the appointment,

Mr. Edward R. Bacon, President Edward R. Bacon Co.

effective immediately, of Edward R. Bacon as its sales representative in San Francisco and northern California. The Bacon Company will handle the entire Byers' line, including ½ yd., ¾ yd., 1 yd. and 1¼ yd. shovels, cranes, draglines, trenchers and skimmers.

W. R. Macatee District Engineer for Cement Association

The Portland Cement Association announces the appointment of Walter R. Macatee as district engineer in charge of association work in the states of Virginia and North Carolina, with offices at 904 E. Main St., Richmond, Va.

For several years past Mr. Macatee has been engaged in road promotion throughout the southeastern states. During 1926 he was in charge of district office at Jacksonville, Fla., later going to New Orleans.

Mr. Macatee is a native of Virginia and served as captain in the marine corps in the World War.

New Detroit Quarters for Cutler-Hammer

Effective Feb. 10 the Detroit district sales office of Cutler-Hammer, Inc., pioneer manufacturers of electric control apparatus, will be located at 2755 E. Grand Blvd., Detroit, Mich., according to announcement issued from the home office at Milwaukee, Wis.

The new location includes warehouse facilities where stocks of standard C-H motor control, wiring devices, safety switches and other C-H products will be carried for immediate delivery.

Smooth, *dustless Roads*

Economical to build and maintain

ROADS that will not withstand year 'round heavy traffic can be improved without discarding the present paving. Just bring them up to date.

Such roads can be made into modern, farm-to-market highways with various treatments combining mineral aggregate with Standard Asphalt Road Oil or Stanolind Cut Back Asphalt. These road treatments do not strain the construction budget.

Thousands of miles of such improved highways in the Middle West have given many years of service with little expense for upkeep.

It will pay you to investigate before you build. Fill in the printed form below and mail it for full information.

Wisconsin State Highway No. 13 in course of construction. Treating subgrade of gravel with Standard Asphalt Road Oil. 300 to 400 yards of gravel to the mile. When completed, it is a good road in all kinds of weather.

Missouri Highway. Mixed-in-place Method, using Standard Asphalt Road Oil and three inches of gravel. Thousands of miles of road built by this method are giving good service in many counties and cities in the Middle West.

Linn County, Iowa. Retread construction. Showing first application of Stanolind Cut Back Asphalt mixed in place with mineral aggregate. September, 1929.

One of these four types of road surfacing will meet your present traffic conditions

Treatment of Sub-grades with Standard Asphalt Road Oil builds up a smooth, dustless, all-weather highway at very low cost. This method of building conserves the material gravel supply, and in this way it greatly reduces the cost of the road.

Mixed-on-the-Road Method of combining Standard Asphalt Road Oil and Gravel gives a three-inch bituminous bound, smooth surface. This type of road can ordinarily be constructed and maintained as cheaply as an ordinary gravel road.

Surface Treatments with Stanolind Cut Back Asphalt are used successfully wherever the road to be treated is constructed of a well compacted mineral aggregate.

Stanolind Cut Back Asphalt retread (or mixed-in-place method) is an economical means of salvaging old bases of gravel or crushed rock. This type of pavement, mixed on the road, is constructed by mechanical means, which results in very low construction costs.

STANDARD OIL COMPANY *(Indiana)*

STANDARD OIL COMPANY (Indiana)
910 South Michigan Avenue, Chicago, Illinois
Send me specifications and other information regarding asphalt and road oil for building good roads.

Name .....

Address .....

City ..... State .....

225

Asphalt and road oil for low cost improved roads

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Happy New Year Everybody

1929 is now ancient history and to all the new friends we have made during the past year, together with all the old friends, we wish, for each and every one, the happiest and most prosperous year that one friend could wish for another.

Distributor News, along with all the other sections of our paper, has tried to serve you faithfully and well, and is looking forward with pleasure to continued cooperation. The manufacturers and distributors have come to realize, we believe, that there is a permanent place in the magazine for their news stories, and the other readers know that any information they may wish concerning the makers of the products which serve them is cheerfully furnished by this department.

Service Exchange has held out a helping hand all year to manufacturers seeking representatives, and distributors wishing to make connections for additional lines, and if our correspondence file is any measure of its success it has established a permanent place in Distributor News.

O. A. Stellar Made Ad Manager for McEverlast, Inc.

Announcement has been made by McEverlast, Inc., to the effect that Mr. O. A. Steller, formerly editor of "Concrete" magazine, has been appointed as advertising manager for their organization.

It is stated that the rapid growth of the McEverlast activities in all sections of the United States and foreign countries has made it necessary to enlarge the general staff and to center activities having to do with the distribution of information regarding the McEverlast products in the newly created publicity department. Mr. Steller's background of engineering, technical advertising and editorial experience starts him in his duties well equipped.

Previous to his connection with "Concrete," Mr. Steller was employed by the Portland Cement Association in the Chicago headquarters. He served this organization in both the road bureau and in the advertising and publications bureau. During the more than ten years with these two organizations, Mr. Steller has traveled extensively, visiting engineering projects and consulting with engineers in every section of the country. He has contributed engineering articles to a great many engineering magazines and has been active in engineering society attendance. He is now 39 years old.

Mr. Steller received his technical education at Marquette University and the University of Wisconsin, and secured his first practical experience in mining projects for the Peabody Coal Company, the engineering staffs of the Wisconsin Highway Commission, the Chicago, Milwaukee, St. Paul & Puget Sound Railway, the Chicago, North Shore & Milwaukee Electric Railway, and the U. S. Geological Survey.

In announcing the appointment of Mr. Steller, the McEverlast Company believe that they have strengthened the staff of their organization, which means another step forward in keeping with their progressive policies.

Announcement

On and after Jan. 2, 1930, the interests of the Worthington Pump & Machinery Corporation in the California territory will be served through a local company, the Worthington Machinery Corporation of California, Ltd., with headquarters at Los Angeles and San Francisco.

Mr. H. D. Cornell, who has been president of the Worthington Machinery Corporation of Oklahoma, will be president of and direct the new corporation, moving to California for that purpose. Mr. George W. Hawkins, who has been the director of sales, will also go with Worthington-California, as vice-president.

The Worthington Machinery Corporation of California, Ltd., will take over the sales and engineering staff and the warehouse facilities of The Worthington Company, Incorporated, in California, and will hereafter handle all that territory.

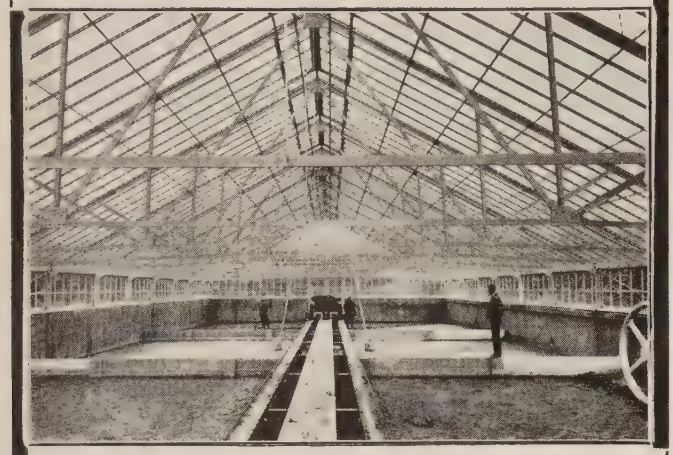
This arrangement will enable the carrying of larger and more diversified stock of Worthington products and parts, and give more prompt service to the increasing number of Worthington friends and customers in California.

The above announcement was issued from the New York office of the Worthington Pump & Machinery Corporation, who believe that the new arrangement will be more acceptable to their patrons by making possible improved service.

On Their Way

The gentlemen strolling up the street are all officials of the Parsons Company, Newton, Iowa. They have recently been to Atlantic City, where the 1930 Road Show was held. Reading from left to right, they are: James McElroy, Director of Agencies; N. DeWind, vice-president, and W. E. Raftery, field sales manager. Mr. McElroy and Mr. Raftery make their headquarters in New York.

Sludge Bed Capacity TREBLED By Glass Enclosure



All-Weather Drying, with Double the Efficiency, Made Possible by King Sludge Bed Enclosures

A necessary requirement of modern sewage disposal is rapid and uninterrupted sludge drying. This is effectively accomplished by King Sludge Bed Enclosures.

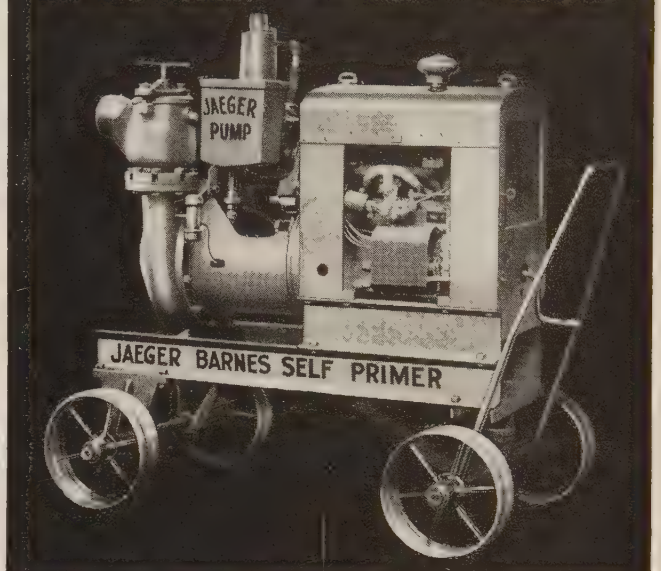
King Enclosures speed up the drying process and eliminate the serious seasonal aspects—the evaporation continues in all kinds of weather and throughout the winter. This practically trebles the capacity of the beds, making it practicable to serve three times the population with the same sludge-bed area which originally was open. Offensive odors are also controlled.

Let us furnish you with complete information. No obligation! Write today.

KING CONSTRUCTION COMPANY
533 Wheatfield St., North Tonawanda, N. Y.

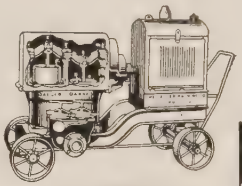
NEW YORK CITY PHILADELPHIA, PA. BOSTON, MASS.
SCRANTON, PA. TOLEDO, OHIO SCHENECTADY, N. Y.
BRIDEPORT, CONN.

Goodby Primers and Foot Valves!



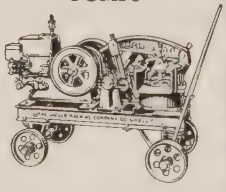
Jaeger-Barnes SELF PRIMING Centrifugals *are Always Ready to Pump*

Get 3 times the capacity in one 100% automatic, continuous high vacuum pump. Sizes for any job...gasoline or electric. Puts other types out of date. Write for catalog and prices.



PLUNGER PUMPS

DIAPHRAGM PUMPS



TRIPLEX ROAD PUMPS

JAEGER MIXERS—PUMPS—HOISTS
Information Slip

THE JAEGER MACHINE CO., 224 Dublin Ave., Columbus, Ohio

Send catalog and prices on ☐ Pumps, ☐ Non-Tilt Mixers, ☐ Tilters, ☐ Timken Roller Hoists.

Name _____

Address _____

Neville & Cleary to Represent Simplex Valve & Meter

The Simplex Valve & Meter Company announces the appointment of Neville and Cleary, Inc., Candler Building, Atlanta, Ga., as its representative for the sales of its products in the territory south of Virginia, West Virginia and Kentucky line, and east of the Mississippi River.

Mr. T. J. Cleary, president, and Mr. W. D. Taulman, secretary-treasurer of the distributor organization, are well acquainted with the Simplex products, having had wide experience in central stations, industrial power and filter plants.

Mr. A. C. Hays will be in charge of the branch office at New Orleans, La.

Fred D. Holdsworth

Fred D. Holdsworth, Engineer in Charge of Air Compressor Design for the Sullivan Machinery Company at its Claremont, New Hampshire, plant from 1900 to 1928, died November 20th. Mr. Holdsworth was born in Wales, Mass., October 23, 1867. He graduated from the Worcester Polytechnic Institute in 1888, and after experience as Mechanical Engineer with the Rhode Island Locomotive Works and with the G. F. Blake Company, afterwards Blake & Knowles, he joined the Sullivan staff in 1900, remaining at Claremont as Mechanical Engineer in Charge of Air Compressor Design until his retirement, about a year ago.

The development of the Sullivan Angle Compound Air Compressor, Portable Gasoline Engine Driven Air Compressor, and Electric Motor Driven Mine Car Air Compressor took place under his direction.

He was awarded nearly fifty patents connected with the development of various Sullivan machines.

Mr. Holdsworth was a member of the American Society of Mechanical Engineers, and had been secretary of the Green Mountain Branch. He was active in civic affairs, serving on the Claremont school board, etc. Mrs. Holdsworth, a son and a married daughter survive him.

E. H. Pearson

The sudden death of Mr. E. H. Pearson on Dec. 7 came as a great shock not only to his associates in the Electric Machinery Manufacturing Company, but to his friends throughout the country. His loss is keenly felt.

Mr. Pearson was born in Malmo, Sweden, in 1893, where is spent his early life and received some of his technical education at the Institute of Technology in Malmo. On coming to Minneapolis, he started work with Crown Iron Works as an electrician, continuing his technical education at the Dunwoody Institute in Minneapolis.

In 1916, Mr. Pearson entered the employ of Electric Machinery Company as a service engineer for the Minneapolis district. In 1920 he was transferred to the New York office, where in the fall of 1921 he entered the sales organization of the company. In 1928 he became manager of the New York district office, which position he held at the time of his death.

He was a member of the American Society of Refrigeration Engineers, the American Society of Swedish Engineers of Brooklyn, N. Y., and the American Institute of Electrical Engineers.

Harry L. Monroe

Following a long illness, Harry L. Monroe, commercial vice-president of the General Electric Company, with headquarters at Chicago, died at Dallas Tex., on Jan. 7. Mr. Monroe completed 40 years of service with the company in September, 1928, six months after his election to the vice-presidency.

Mr. Monroe was born in Parkersburg, W. Va., in 1869. He entered the employ of the company in 1888, with the Thompson-Houston Company in Chicago. In 1890 he was transferred to the railway department, and in 1894 became a salesman operating out of the Dallas office of the General Electric Company. He was made manager of the railway department of the central district in 1905, and eight years later was named district sales manager, and later district manager of the central district, with offices in Chicago.

J. D. Capron Joins Glamorgan Company

Mr. J. D. Capron, for many years publicity manager of the United States Pipe & Foundry Company, Burlington, N. J., has resigned from that company to become general manager of the Glamorgan Pipe & Foundry Company, Lynchburg, Va., according to announcement recently given out. Mr. Capron will be succeeded as publicity manager by Mr. S. E. Linderman.

Mr. Capron is well known in the field of technical advertising and among the engineering profession, and has held prominent positions in the T. P. A.

Another Distributor for Trackson Company

The Valley Equipment Co., 2508-14 N. Broadway, St. Louis, Mo., has been appointed distributor for the Trackson lines of crawlers, loaders, shovels, cranes, hoists, bulldozers, hitches, etc., for the McCormick-Deering Tractor, manufactured by the Trackson Company, 500 Clinton St., Milwaukee, Wis. They will cover the St. Louis territory and will be able to fill orders and furnish repair parts promptly. Herman Ehlig is manager of the Valley Equipment Co.

House Magazines*

Editor's Note: This column is published every now and then. Many most attractive and interesting house magazines come to our desk from time to time, and we take this method of acknowledging them.

The U. S. Piper, published quarterly by The United States Pipe & Foundry Company of Burlington, N. J., has just completed its second volume, and the last issue received (December) is a most interesting little pamphlet. It contains an illustrated article on the Development of Distribution System of the Dallas City Water Works; an article on Bitumastic Lining for cast iron pipe; an editorial on Adequate Aqueducts, and other equally interesting material. Mr. Ralph M. Shaw, Jr., is the editor of this paper.

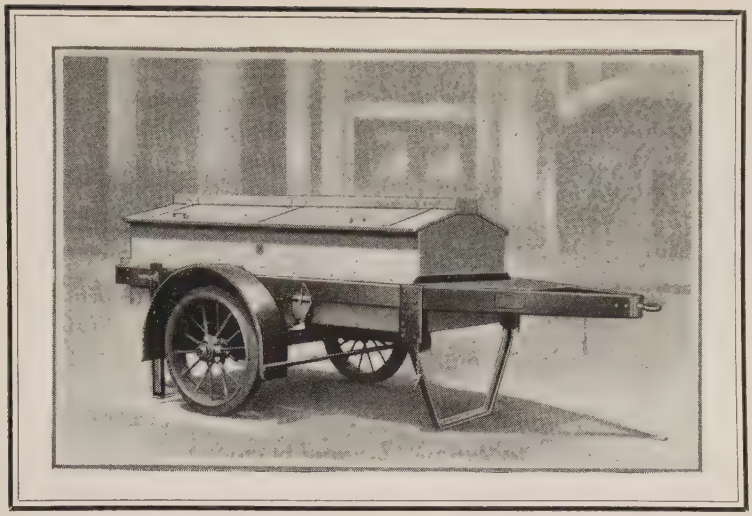
The Spiral Stripe is another attractive house organ issued by A. M. Byers Company, Pittsburgh. This little paper is filled with interesting and detailed descriptions of factories, schools, homes and other types of buildings where the wrought iron pipe of this manufacturer has been installed. Among the plants described are the Rayon Mills of the American Chatillon Corporation, Rome, Ga.; Columbia High School at Maplewood, N. J.; Canfield Oil Company, Coraopolis, Pa.; John Dieckmann's Greenhouses at Wheeling, W. Va., and many others.

The Amsco Bulletin, issued by the American Manganese Steel Company, Chicago Heights, is filled with illustrated details of Fahralloy, a name given to a series of chromium and nickel alloys, each made for a particular condition requiring heat and corrosion resistance.

Bores & Strokes for December comes from Schramm, Inc., West Chester, Pa., bearing the Season's Greetings and many interesting notes and pictures of the Schramm compressor "on the job." H. W. Moore Equipment Co. of Denver are featured in this number as distributors of Schramm."

The Monarch Operator, the official organ of the Monarch Operators' Club, the purpose of it being to arouse enthusiasm and maintain contacts between Monarch tractor operators throughout the world. Members of the club, who must be Monarch operators vouched for by dealers and distributors, and holding membership cards, are contributing writers for the magazine, furnishing stories and pictures of actual experiences in the field. A prize picture contest is now underway for the best pictures of Monarch tractors in action. All Monarch tractor operators the world over are invited to join this club. Information may be secured from dealers or by writing the Tractor Division of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

*Manufacturers named will be pleased to send above mentioned publications to readers upon request.



THE HEAVY DUTY TOOL BOX

TOOL BOXES
Made of Steel

LITTLEFORD TOOL BOXES are not only made of steel mounted on strong running gear—they are made for accommodation of tools and equipment used by maintenance departments. In three styles—Heavy Duty, Utility (both portable), and Stationary. There is a size and price for you. Write for complete information. You'll be under no obligation.

Littleford Compound Furnaces are made in 25 and 50 gallon sizes, both oil and wood burning types.

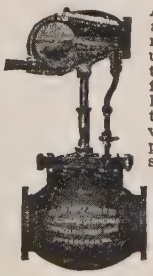
STEEL BOXES FOR EVERY PURPOSE — LB — LITTLEFORD BROS. CINCINNATI, OHIO

LITTLEFORD
ALL-STEEL
TOOL BOXES

LITTLEFORD BROS. 454 E. PEARL ST. CINCINNATI, O.

GOLDEN-ANDERSON

GOLDEN-ANDERSON
Patent Automatic Cushioned Controlling Float Valves



Adapted to automatically maintain a uniform water level in feed-water heaters, tanks, reservoirs, and pans. Very sensitive.

Operating on ½-in. to ¾-in. variation. No exhaust or expensive water waste. Can be furnished for hot or cold initial water supply. Reliable and dependable under varying pressure.

Sizes ½ in. to 24 in.

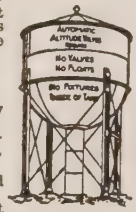
Automatic "Cushioned" Controlling Altitude Valves
Cushion All Water Surges

Automatically maintains a constant stage of water in reservoirs, tanks and standpipes. They do away with the annoyances of Freezing Valves and Float fixtures inside of the Tanks or Floats and Fixtures outside of Tanks. "Three Ways of Closing These Valves."

1st—Automatically, by water.
2nd—By electricity, if desired.
3rd—By Hand.

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe.

The double cushion effect of air and water eliminates water hammer. There are no dangerous surges to burst water mains. **Write for details.**



REMEMBER Valves cushioned at all times by air and water. No water hammer or bursting mains.

"Made with stop starter attachment for centrifugal pumps."

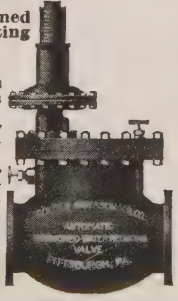
Golden-Anderson Valve Specialty Co.

1385 Fulton Bldg., Pittsburgh, Pa.

GOLDEN-ANDERSON
Patent Cushioned Water Relief Valves

1. Automatically relieve excess pressure.
2. Prevent stress, strain and bursting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and globe pattern. Sizes 3 to 24-in.

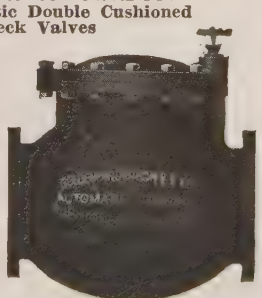
GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Pressure Regulating Valves



1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

GOLDEN-ANDERSON
Pat. Automatic Double Cushioned Check Valves

1. Especially adapted for Water Service.
2. For High or Low Pressure.
3. Thoroughly Cushioned. No Chattering, Hammering, or Sticking.
4. Globe or Angle Patterns up to 24 in.
5. Especially adapted for hydraulic elevator service.



GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipe, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle—Most Satisfactory Float Valves known.
4. No Metal-to-Metal Seats—No Water Hammer or Shock.
5. Cushioned by Air and Water.

Sizes ¼" to 24".

National Equipment Becomes Operating Organization

Announcement has been made that on Jan. 1, 1930, the National Equipment Corporation became an operating company. This organization is a consolidation of the Koehring and T. L. Smith Companies of Milwaukee, the Insley Manufacturing Company of Indianapolis, The Parsons Company of Newton, Ia., and the Kwik-Mix Concrete Mixer Company of Port Washington, Wis.

Headquarters of the corporation are located at 31st St. and Concordia Ave., Milwaukee. Mr. Philip A. Koehring is president and general manager.

Sales, service, advertising and accounting departments have been centralized, with a view to more efficient service to customers, as well as effecting economies in operation and overhead.

Mr. R. E. Brooks, for a number of years engaged in the equipment business in New York, was recently elected vice-president and will be in charge of sales.

The officers of the National Equipment Corporation are: P. A. Koehring, president and treasurer; W. H. Insley, vice-president; H. E. Smith, vice-president; H. C. McCardell, vice-president; W. J. Koehring, vice-president; R. E. Brook, vice-president; W. J. Zimmers, secretary; G. E. Long, comptroller; and C. A. Koehring, assistant treasurer.

E. L. Carpenter Appointed to Hoover Survey Conference

Announcement has been made of the appointment of E. L. Carpenter, president of the National Lumber Manufacturers' Association, as a member of the executive committee to carry out the business stabilization projects contemplated by President Hoover.

Others who will serve on this committee are:

Owen D. Young, chairman of the board of the General Electric Company; Myron C. Taylor, chairman of the finance committee of the United States Steel Corporation; Thomas W. Lamont, of J. P. Morgan & Company; Paul Shoup, president of the Southern Pacific Company; and Clarence M. Woolley, chairman of the American Radiator Company.

Henry M. Robinson, president of the Los Angeles First National Trust & Savings Bank; Walter C. Teagle, president of the Standard Oil Company of New Jersey; James Simpson, president of Marshall Field & Company, Chicago; C. F. Kelley, president, Anaconda Copper Mining Company; Pierre S. duPont, Wilmington, Del.; Lewis E. Pierson, Irving Trust Company, New York City; George Horace Lorimer, editor, Philadelphia; Walter S. Gifford, president, American Telephone and Telegraph Company; Alvin Macauley, president, National Automobile Chamber of Commerce, Detroit.

E. L. Carpenter, of Shevlin, Carpenter, Clark Company, Minneapolis, Minn., President of the National Lumber Manufacturers' Association, Who Has Been Named to the Executive Committee of President Hoover's National Business Survery Conference

John G. Lonsdale, president, American Bankers' Association, St. Louis; Steuart C. Cramer, director, Cotton Textile Institute, Cramerton, N. Car.; Charles Cheney, president, National Industrial Conference Board, Manchester, Conn.; Silas H. Strawn, chairman of Montgomery Ward & Company, Chicago; and Harry Chandler, publisher, Los Angeles.

Charles Piez Elected President A. S. M. E.

Charles Piez, chairman of the board of Link-Belt Company, was made president of the American Society of Mechanical Engineers, held in New York City recently. He is widely known as an engineer, manufacturer and executive.

Mr. Piez was born in Germany in 1866, of naturalized American parents. He received his technical education as a mining engineer at the School of Mines, Columbia University, his own earnings going to pay for his education. After graduation he entered the employ of the Link-Belt Engineering Company at Philadelphia as an engineer draftsman at $65 a month. Seventeen years later he was made president of the Link-Belt Company, a consolidation of the Link-Belt Machinery (Chicago), the Ewart Manufacturing Company (Indianapolis), and the Link-Belt Engineering Company (Philadelphia). This organization now has twelve factories in eight cities, and sales offices throughout the world.

Largely as a result of his fame as an organizer and manager of industry, Mr. Piez was selected in November, 1917, to be vice-president and general manager of the United States Shipping Board Emergency Fleet Corporation, to carry out the nation's shipbuilding program. In this undertaking he was associated with Mr. Charles M. Schwab, whom he later succeeded as director general. He had control over 600,000 persons employed in the shipyards and fabricating plants, and industries furnishing supplies to the yards, and directed the expenditure of three billion dollars.

At the close of the war, Mr. Piez returned to his private business, continuing as president of the Link-Belt Company until 1924, when he became chairman of its board of directors.

In addition to being president of the Society of Mechanical Engineers, he is president of the Commercial Club of Chicago; a director of the Foreman State National Bank of Chicago and the Drexel State Bank of Chicago; director of the Illinois Bell Telephone Company; a member of the executive committee of the Museum of Science and Industry, founded by Julius Rosenwald, and a member of the American Institute of Mining and Metallurgical Engineers, Society of Naval Architects and Marine Engineers, Western Society of Engineers and Engineers of Northeastern Pennsylvania.

Mr. Piez was president of the Illinois Manufacturers' Association in 1911-1913, and again in 1924-25. As a member of the commission that drew the state factory act he was instrumental in framing much of the labor legislation in the State of Illinois. He was chairman of the Workmen's Compensation Commission, and a member of the State Arbitration Board.

Charles M. Nuckolls Joins H. D. Conkey & Company

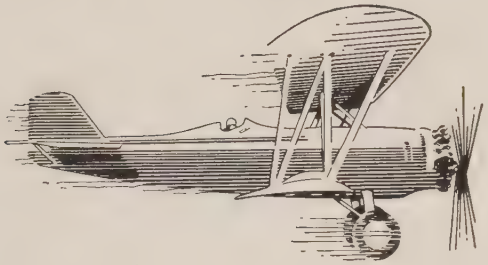
According to announcement Charles M. Nuckolls, formerly with the International Harvester Company, Chicago, has accepted a position with H. D. Conkey & Company of Mendota, Illinois.

Prior to his connection with the International Harvester Company, Mr. Nuckolls was associated with the Whiting Corporation, Harvey, Illinois, and the Shaw Crane Works, Muskegon, Michigan.

Wanted Sales Engineer

A contractors' equipment sales engineer to travel throughout the United States, under 40 years of age and, if possible, with an acquaintance among distributors, is being sought by manufacturer. Adequate salary and expenses plus commission is offered. Send your application to Distributor News, stating age, education, experience and past earnings. Same will be forwarded to manufacturer and will be held confidential.

McWane Pipe for the Air Mail!



Perhaps you have not connected McWANE Cast Iron Pipe with the Air Mail—except that both are leaders in progress! . . . But air mail requires air ports. And air ports require the best and most reliable of construction materials. Which naturally meant McWANE Precalked Joint Pipe at this Oregon air port.

WHY McWANE PIPE SUCCEEDS

50% greater tensile strength—30% greater transverse strength than A.W.W.A. specifications ask. Sand cast, yet modern weights. B. & S. type. Standard lengths. Precalked Joint Fittings, too. Write for literature.

WRITE FOR ILLUSTRATED LITERATURE

McWANE CAST IRON PIPE

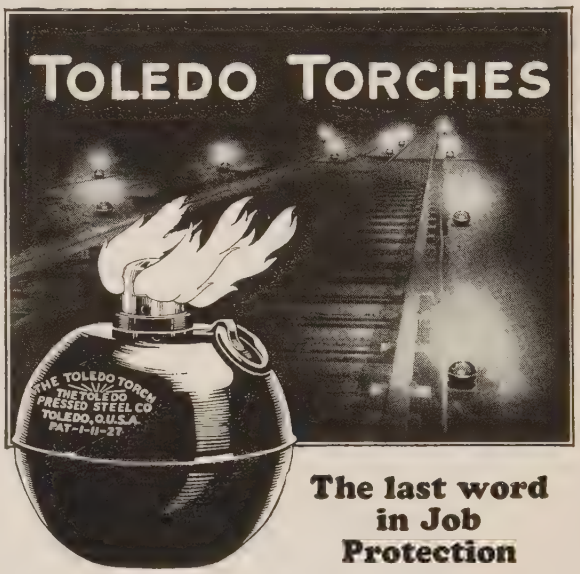
McWANE CAST IRON PIPE COMPANY
BIRMINGHAM, ALA.

PACIFIC STATES CAST IRON PIPE COMPANY
PROVO, UTAH.

SALES OFFICES IN PRINCIPAL CITIES

Don't Blame Accidents on Bad Luck

You don't have them!



The last word in Job Protection

There is no longer any excuse for accidents on open construction work. Toledo Torches not only protect *better* than all other safety lights—they also do it more *cheaply.* Their universal use is the best proof that they fill the bill. You can't go wrong with Toledo Torches, equipped with the *patented* Economy Burner. They are guaranteed. Call or write your dealer now, or write us.

The Toledo Pressed Steel Co.
Toledo, Ohio

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Equipment distributor in Pacific Northwest desires line of road building equipment, structural building equipment, dump bodies and truck hoists.

Distributors of contractors' and builders' machinery and equipment are seeking line of road forms, road finishers, batcher plants, clamshell buckets and drag line buckets, for northern California terirtory. Now stocking equipment for several well known machinery manufacturers.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Road machinery distributor would like to secure exclusive sales rights for state of Mississippi for line of automatic or self-loading wheeled scraper.

A Michigan distributor, with many years' experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing increased facilities in this region.

Manufacturers' representatives located in New York would like to add line of heavy contractors' equipment of established reputation, other than the lines now handled by them. They would like exclusive sales rights for such equipment.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Equipment distributor located in Michigan desires to add two or three good lines to serve territory in southeastern part of state.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Distributor covering New Jersey and New York territory would like to secure a line of street markers or other traffic equipment on exclusive basis.

Distributor of building specialties covering a territory of 100 mile radius from Chicago is equipped to represent additional lines.

Machinery distributor established in Porto Rico and Santo Domingo would be pleased to make arrangements to take on new lines in these territories.

Machinery company in the east is interested in representing established lines of road machinery, with the exception of graders.

Distributor thoroughly familiar with bituminous materials and equipment for handling, wishes to add to present lines. Covers Wisconsin and Illinois territory.

Representatives Wanted

Manufacturer of truck, adapted to many uses, has attractive territory open in Missouri, Kentucky, Kansas, Nebraska and several southern states.

Manufacturer of hoisting machinery and air compressors has open territory in New York and New England states for aggressive distributor.

Manufacturer of excavating equipment desires to build up distribution organization throughout the country.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Attractive territory available for experienced men to handle contractors' labor-saving equipment by old established company. Equipment backed by national advertising.

A manufacturer of paving expansion joints is looking for distributors for northern California territory.

Manufacturer of metal lath, corner beads, channels and reinforcing mesh desires to secure distributors for products in the southwest and middlewest.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Manufacturer of metal tie and spacer wishes to establish distributing points throughout the country.

Manufacturer of mechanical spreaders for cover material desires representation by organizations covering entire states. Several desirable states are still open. Number of inquiries now on hand for spreaders require immediate follow up.

Manufacturer of automatic dipper trip, adapted to any type shovel (steam, gasoline, diesel, electric, etc.); with rapidly growing business, is seeking additional representatives.

Manufacturer of complete line of construction equipment, mixers, saw rigs, plaster and mortar mixers and pumps has an open territory in the state of Maine and is looking for an aggressive distributor to represent him there.

Manufacturer of rotary pump, especially designed for road construction work, has proposition for reliable distribution houses.

Good side-line offered to manufacturers' representatives covering municipalities and public institutions.

Long established and well-known manufacturer of industrial locomotives wishes to make contacts with qualified distributors. Locomotive line includes steam, gasoline, gas-electric and oil-electric. Supported by national trade journal advertising.

Manufacturer of air compressors and contractors tools has number of desirable territories open. Full co-operation will be extended to distributors.

TO GIVE THE PEOPLE THE MODERN, CONVENIENT TELEPHONE SERVICE THAT THEY NEED

The Bell Telephone Company . . . of your town

An Advertisement of the American Telephone and Telegraph Company

It has its home in your town. Its operators are the daughters of your neighbors. Its various departments are in the hands of your own citizens, with years of training in telephone engineering and management. Who owns the Bell System? 450,000 people scattered over the United States own the stock of the American Telephone and Telegraph Company and 250,000 own other securities of the Bell System.

No matter how small the part of the Bell System that serves you, it has behind it research, engineering and manufacture on a national scale. The Bell System operates through 24 companies, each designed to fit the particular area it serves—to furnish the highest standard of service in a manner personal to the needs of every user.

Serving each of these 24 operating companies is the staff of the American Telephone and Telegraph Company, which is constantly developing better methods of telephone communication. Each draws on the findings of the Bell Laboratories, one of the greatest institutions of its kind in the world, for the continual scientific improvement of telephone service.

Each has the benefit of the buying power and specialized manufacturing processes of the Western Electric Company, which supplies telephone apparatus of the highest quality and precision for the entire Bell System.

Each takes advantage of every improvement in practice, equipment and economy.

The Bell System's ideal is to give all of the people of this nation the kind of modern, convenient telephone service that they want, over its wires to connect them one with another and with the telephones of the rest of the world. It is your telephone company, at your service with every resource that it commands.

AMERICAN TELEPHONE & TELEGRAPH CO. AND ASSOCIATED COMPANIES — BELL SYSTEM

DISTRIBUTOR NEWS

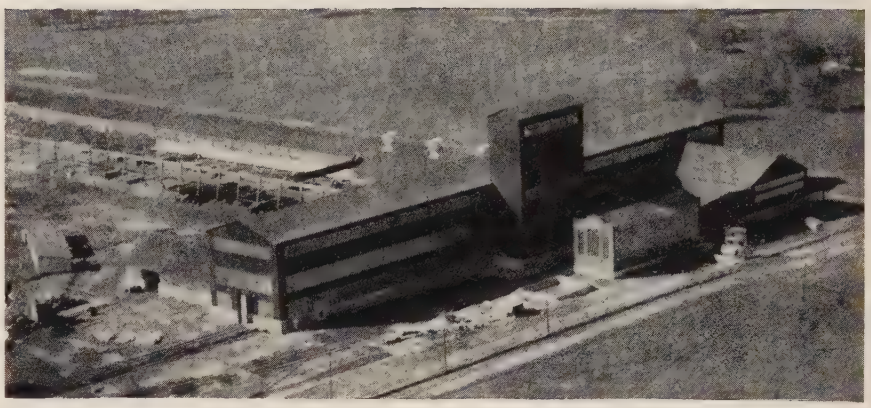
The Distributor's Department in the Gillette Construction Group

Chicago Bridge & Iron Works Buys Large Southern Plant

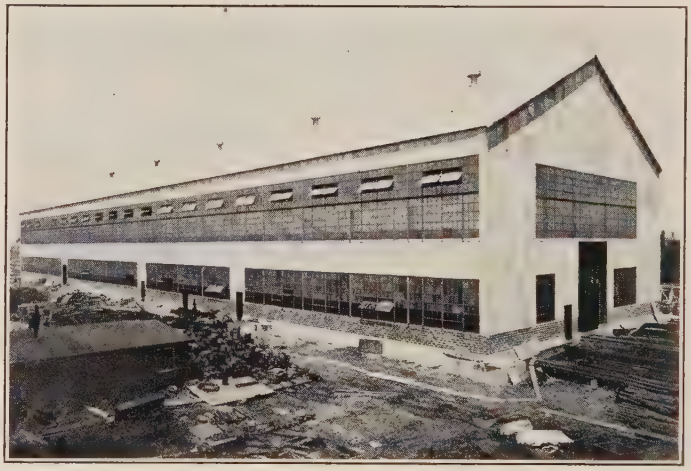
The Chicago Bridge and Iron Works has purchased the Reeves Brothers Company steel plate fabricating plant in Birmingham, Ala., thus establishing a plant of their own in the south. In addition, the Chicago Bridge and Iron Works maintains plants in Chicago, Ill., and Greenville, Pa.

The Reeves Brothers plant was completed in 1925 and includes all of the modern developments and improvements in steel fabricating plants. It is located on a square 40-acre tract, a short distance from the main business district of Birmingham. E. E. Michaels, formerly assistant manager of operations in Chicago, is now located in Birmingham as manager, while the sales organization is under the supervision of James C. Vosburgh, former district sales manager of San Francisco. The major part of the local organization of the plant has been retained. In addition, quite a number of the employees of the main office in Chicago have been transferred to the Birmingham office. W. J. Lawson is foreman of the erection shop, while Fred J. Miller is the purchasing agent.

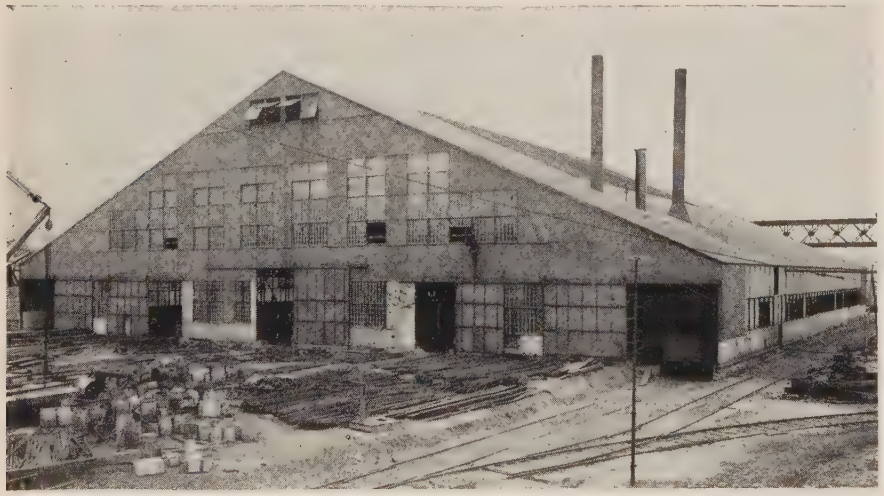
In reviewing the history of the company, it is found that the organization of the Chicago Bridge and Iron Works dates back to the early part of 1889, the charter being taken out on July 27. The formation of this company included the purchase of all business interest of the Kansas City Bridge and Iron Company. Kansas City was not deemed to be the logical location, so the plant was located in Chicago under the name of the Chicago Bridge and Iron Works.



Aerial View of Birmingham Fabricating Plant Recently Acquired from Reeves Brothers by Chicago Bridge & Iron Works



Main Plate Shop Building of Chicago Bridge & Iron Works (Horton Steel Works, Ltd.) at Bridgeburg, Ontario



An Early View of the Chicago Plant of the Chicago Bridge & Iron Works

Offices were located at Kansas City, Austin, Tex., St. Paul, Minn., and Chattanooga, Tenn. These outside offices were seeking contracts for highway bridges, the chief output of the plant at that time. On September 25, 1897, the plant was entirely destroyed by fire and the two alternatives offered were liquidation or rebuilding. Mr. Horton became sole owner of the company and formulated plans for a new plant in Washington Heights, which marks the present plant in Chicago.

Up to 1893, the business was solely confined to the building of bridges, but in the summer of 1893, the first standpipe was erected at Lake City, Ia., after

H. H. ROBERTSON CO.,
PITTSBURGH, PA.

THE MOST IMPORTANT INGREDIENT IN YOUR PIPE COATING IS

EXPERIENCE

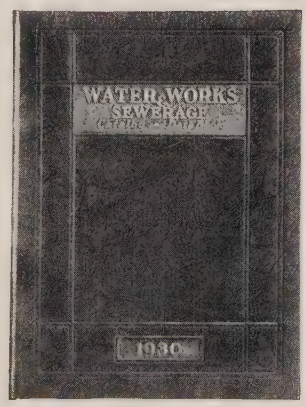
The best solution to any of the problems that come up in the business of coating pipes is knowledge. Robertson has the knowledge. The H. H. Robertson Co. is the world's largest producer of special asphalts. It has made investigations in the action of soils on coating materials. It can determine the exact combination of asphaltic bases that are best calculated to protect your pipe under any given set of conditions . . . and it can produce exactly that combination.

Specify Robertson coatings on your pipes.

ROBERTSON HAS THE EXPERIENCE

Announcing the 1930 edition of

WATER WORKS AND SEWERAGE CATALOG AND DATA BOOK



Mister Reader!

Have you asked to have a copy of this Catalog reserved for you? It will be ready for distribution the 1st of June. The 1930 edition will be handsomely bound in dark maroon, leather finished, fabric.

This will be the second annual edition, which will appear as an independent volume, having no connection with the magazine of the same name.

Contents will be equivalent to a 250-page handbook of reference data. Information on Water Mains, Pumping Stations, Reservoirs, Sewage Works, Sewer Systems, Chlorination Meterage, Filtration Plants Operation.

Catalog descriptive of every type of equipment, material and chemical used in design, construction and operation of water works and sewerage.

GILLETTE PUBLISHING COMPANY
221 East 20th Street, Chicago

Gillette Publishing Co.
221 East 20th St., Chicago

Kindly reserve for me a complimentary copy of the 1930 edition of the Water Works and Sewerage Catalog and Data Book.

Name.....
Occupation or Title.....
Street Address.....
City.....State.....

which numerous orders were received for steel towers to support wood tanks. In 1894, the Company built its first hemispherical bottom steel tank. Prior to that time, elevated tanks consisted of a flat bottom wood or steel tank on an I-beam grillage mounted on a wooden or steel tower. The hemispherical bottom type is supported entirely by its connection with the bottom of the shell, the whole tank being supported by columns riveted directly to it. In 1907, the ellipsoidal bottom design was introduced, especially adapted to railroad service.

Installations increased in the eastern and southern districts. In 1910, a sales office was opened in New York and a plant in Greenville, Pa.; operation beginning in 1911. Interest was first aroused in Canada by the securing of a contract by Mr. Horton for the erection of a standpipe for the town of Pictou, N. S., in 1901. In 1913, business in Canada showed a marked increase. It was thought expedient to organize a company in Canada (Horton Steel Works, Ltd.), and Bridgeburg, Ontario, situated on the west bank of the Niagara river, was chosen as the location. Plant operation began in 1913, and the Bridgeburg plant has more than doubled its size. The main office is located at Bridgeburg, with branch offices at Montreal, Toronto, Winnipeg and Vancouver.

The Birmingham plant therefore, marks the third of the fabricating plants operated by the Chicago Bridge & Iron Works, thus serving the central states via Chicago, the eastern states via Greenville, and the southern area via Birmingham.

The building of oil storage tanks and general plate construction began in 1920. Hortonspheres, which are spherical pressure tanks, made their appearance in 1925. Wiggins Floating and Breather Roofs are another development, protecting oil tanks from evaporation and fire.

The Chicago Bridge and Iron Works has greatly increased its range of materials manufactured, and specializes in the design, construction and erection of oil tanks, elevated tanks, smokestacks, gasholders, penstocks. The plant in Birmingham is equipped to handle a larger range of steel work than the other U. S. plants, including the fabrication of agitators, absorbers, bubble towers, condenser boxes, crude stills, tank cars, blast furnaces, galvanizing kettles, steel mill ladles, rotary kilns, vertical kilns, creosoting cylinders, coke oven appliances and many other devices.

A. W. Daniels Made Vice-President American Manganese Steel Co.

The American Manganese Steel Co. announces the election of Mr. A. W. Daniels as vice-president in charge of sales, effective March 26, 1930.

Mr. Daniels was born in Chicago and educated in the Chicago elementary schools. At the age of thirteen he entered the "University of Hard Knocks" —the business world, where a wide diversification of experience in practically every branch of foreign and domestic commerce, manufacturing, accounting, finance, advertising, marketing, sales promotion and executive management prepared him well for the future demands which would be made on him.

For seven years prior to entering the employ of the American Manganese Steel Co. as assistant to the industrial engineer at the Chicago Heights plant, Mr. Daniels traveled extensively as a commercial representative. In 1920 he became the AMSCO Chicago office manager, a position that put him in intimate contact with the voluminous details of the manganese steel business. Two years later he was promoted to central sales manager, which position he occupied but one year before his appointment in 1923 as general sales manager of the American Manganese Steel Co.

Mr. A. W. Daniels

Mr. Daniels is an authority on the markets and marketing of manganese steel and is in complete touch with the developments of the industrial world as applied to the products of the American Manganese Steel Co., and because of his close, personal contact with the leaders of industry, and his keen analysis of business conditions, he is well fitted by experience and knowledge to fill this new position.

Link-Belt Announces New Crane Agents

Link-Belt Company, 300 West Pershing Road, Chicago, Illinois announce the appointment of the following agents who will handle their complete line of Crawler Cranes-Shovels-Draglines, and Locomotive Cranes.

P. L. Tippett, Rhodes Building, Atlanta, Georgia.

Jos. C. Fiorello Co., Larkin Terminal Bldg., Buffalo, New York.

Bacon-Hibbard-Eichman, Inc., 917 Central Avenue, Cleveland, Ohio.

Aerial View of Chicago Plant of Chicago Bridge & Iron Works in 1928

GOLDEN-ANDERSON

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Float Valves

Adapted to automatically maintain a uniform water level in feed-water heaters, tanks, reservoirs, and pans. Very sensitive.

Operating on ½-in. to ¾-in. variation. No exhaust or expensive water waste. Can be furnished for hot or cold initial water supply. Reliable and dependable under varying pressure.

Sizes ½ in. to 24 in.

Automatic "Cushioned" Controlling Altitude Valves

Cushion All Water Surges

Automatically maintains a constant stage of water in reservoirs, tanks and standpipes. They do away with the annoyances of Freezing Valves and Float fixtures inside of the Tanks or Floats and Fixtures outside of Tanks. "Three Ways of Closing These Valves."

1st—Automatically, by water.
2nd—By electricity, if desired.
3rd—By Hand.

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe.

The double cushion effect of air and water eliminates water hammer. There are no dangerous surges to burst water mains. **Write for details.**

REMEMBER
Valves cushioned at all times by air and water. No water hammer or bursting mains.

"Made with stop starter attachment for centrifugal pumps."

Golden-Anderson Valve Specialty Co.
1385 Fulton Bldg., Pittsburgh, Pa.

GOLDEN-ANDERSON

Patent Cushioned Water Relief Valves

1. Automatically relieve excess pressure.
2. Prevent stress, strain and bursting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and globe pattern. Sizes 3 to 24-in.

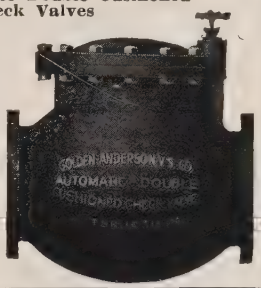
GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

GOLDEN-ANDERSON

Pat. Automatic Double Cushioned Check Valves



1. Especially adapted for Water Service.
2. For High or Low Pressure.
3. Thoroughly Cushioned. No Chattering, Hammering, or Sticking.
4. Globe or Angle Patterns up to 24 in.
5. Especially adapted for hydraulic elevator service.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipe, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle—Most Satisfactory Float Valves known.
4. No Metal-to-Metal Seats—No Water Hammer or Shock.
5. Cushioned by Air and Water

Sizes ⅛" to 24".

TANKS

Bardstown, Ky.—150,000 gallons

. . . for . . .

Municipal Water Works Systems

Wherever water is needed, Pittsburgh-Des Moines elevated tanks, standpipes and steel reservoirs furnish economical, dependable storage. Large cities are giving better water service by installing several tanks for auxiliary storage in their outlying districts. Small communities are improving their systems and insuring steady pressure by installing a single central tank.

Our nearest office will gladly submit designs and estimates of storage tanks for your requirements.

Pittsburgh-Des Moines Steel Company

4 Neville Island, Pittsburgh, Pa.

Des Moines — New York — Chicago
Atlanta — Dallas — Seattle — San Francisco

Ludlow Valve Elects New President and Board Chairman

James H. Caldwell has been elected Chairman of the Board of The Ludlow Valve Mfg. Co., Troy, N. Y., with which he has been associated as a general manager for 41 years, during 27 of which he was also President of the Company.

Always active in the interests of the Waterworks Manufacturers' Association, Mr. Caldwell has served as its President and has been chairman of the Flange Standardization Committee of the Valve Manufacturers' Association.

Born at Mobile, Ala., Mr. Caldwell is a graduate of Rensselaer Polytechnic Institute, Troy, N. Y., and a member of its Board of Trustees. He is also a Director of the Manufacturers' National Bank of Troy, N. Y., and active in philanthropic work, particularly in behalf of the Samaritan Hospital and the Y. M. C. A. of Troy.

Mr. James H. Caldwell

The presidency of The Ludlow Valve Mfg. Co., has been filled by the election of William H. Lolley, who is also Director and General Manager. For a number of years associated with Ludlow interests as Sales and Engineering Consultant, Mr. Lolley brings to his new office wide experience in industrial production, particularly with respect to close precision tools in the automotive and other branches of the metal working industries.

Born in Perth, Scotland, a graduate of Springfield College and Polytechnic Institute of London, Mr. Lolley has represented substantial American manufacturers in England, France and Germany, introducing American products, machinery and methods.

The Ludlow Valve Mfg. Co., was organized and started business in January, 1866, at Troy, N. Y. By 1896

Mr. William H. Lolley

the business had successively outgrown three plants. At that time they purchased the property of the Troy Steel & Iron Co., and at the same time started construction of a new factory along the Hudson River adjoining the N. Y. Central freight yards, thus providing for excellent shipping facilities.

Operations were started at the new plant early in 1897.

Business continuing to expand, an adjacent plot of ground and buildings were acquired and a new foundry measuring 138x367 feet constructed in 1903. At the same time the machine shop was remodelled and enlarged to 210x378 feet.

The Company has recently acquired additional ground and contemplates an increase of production facilities at an early date as part of a program of expansion, diversification of products and general development.

"Everything for the Pool"

Mr. John R. Mudge, manager of the Chemical Equipment Corporation of California, states that his organization can with their own equipment or with equipment for which they are exclusive agents furnish everything needed for the pool.

This company is one of the progressive corporations serving the great state of California. Offices, warehouse and shop facilities are located at 110 N. Alameda St., Los Angeles, where they have plenty of room for future expansion. New machines are carried in stock in order to make immediate delivery and the shop is equipped for making all necessary repairs.

When this company increased their working facilities last fall it was said to be partly because of the rapidly increasing business in the sale and servicing of the Paradon Chlorinators which they represent in California, in addition to the well-known "Chemco Service" and "Everything for the Pool." N. Y. Continental Jewell filters, made in Los Angeles, the Everson vacuum plunge sweeper and the Everson plunge fittings, pumps, hair and lint catchers and other related equipment are some of the reasons for the activities of Chemical Equipment Corporation.

Copper and Brass Pipe Show High Sales

Sales of brass and copper pipe and tubing reached a new high total of 77,992,084 pounds during 1929, according to an estimate just completed by the Copper and Brass Research Association.

Sales in 1929 were practically five times the 16,016,500 pounds sold in 1922, notwithstanding reduced building activity during the year. Sales in 1928 amounted to 76,777,400 pounds.

Statistics compiled by the Association show that since 1922 sales of brass and copper pipe and tubing have increased 387 per cent. The average annual increase for the last six years is 63.67 per cent.

The Chain Belt Company of Milwaukee, Wisconsin announces the appointment of the Corbin Supply Company of Macon, Georgia as representatives for their complete line of chain and transmission equipment.

Rex equipment, made by the Chain Belt Company, includes a broad line of chain and power transmission equipment conveyors and conveying systems for an important series of industries, concrete mixers, pavers, pumps, saw rigs, plaster and mortar mixers as well as a number of allied products.

Sullivan Machinery Company of Chicago announces that Mr. Morley S. Sloman, who has been associated with their Pittsburgh office for the past fourteen years, has been appointed manager at Huntington. Mr. Sloman will succeed Mr. John S. Walker, Jr., who has been manager of the Huntington branch since its establishment in 1912 and who has retired to engage in the banking business.

Van Dyke Transferred To New York

B. Van Dyke, of the Quincy, Ill., sales division of the Gardner-Denver Co., has been transferred to the New York office of the organization. Hendrick Stolk, until recently with Stoksvis & Zonen, of Holland, has just been transferred to St. Louis from the Quincy plant where he completed a sales study course.

Electric Machinery Manufacturing Company announces that after the first of April, their Chicago office will have a new location. The new office will be in Room 1567, 20 North Wacker Drive Building, (Civic Opera Building).

POMONA
Oceans of Water
PUMPS

Cleanest WATER FOR EVERY NEED . . .

There are in the United States over a score of towns and cities that depend solely on Pomona Water Lubricated Turbine Pumps for production of their entire water supply. There is a real reason why city engineers prefer the Pomona. In the first place its performance is most dependable and the water produced is cleanest. The Pump is correctly designed mechanically and hydraulically. Its operation is smooth and vibrationless. Its manufacture is gauged by standardized production methods which assure interchangeable parts. All pumps are serially numbered and every part is correctly recorded assuring correct replacement of parts in the shortest possible time.

Write for name of Distributor or Factory Representative located in all principal cities.

POMONA PUMP CO.
Pomona, California

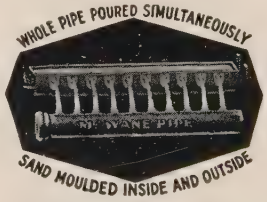
POMONA PUMPS

McWane Pipe "Eats" Curves!

By which we mean that the Precalked Joints round curves in your mains perfectly.—An important factor in these days of curving streets in residential developments.

No lead-pot, no yarning, no pouring, you just "socket and 'sock' it" with a calking hammer to lay McWane Precalked Joint Cast Iron Pipe. "3 times the speed for half the labor."

SAND CAST McWANE Pipe is SAND CAST —yet mod rn in weights and strengths.



SIZE RANGE 1¼ thru 12 inches. Standard lengths. Precalked Joints or open bells.

McWANE 1¼ and 2 inch cast iron pipe with Precalked Joints gives you a permanent pipe in the small diameters, too. Avoid rust with it, at low cost.

WRITE FOR ILLUSTRATED LITERATURE

McWANE CAST IRON PIPE

McWANE CAST IRON PIPE COMPANY
BIRMINGHAM, ALA.

PACIFIC STATES CAST IRON PIPE COMPANY
PROVO, UTAH.

PRINCIPAL CITIES

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Water Works equipment distributor, covering northeastern Indiana, would like to secure represenation of a line of chlorinators.

Manufacturer's representative, covering Massachusetts, Rhode Island and southern New Hampshire, would like to secure line of speed reducers and gears.

Manufacturer's representative now handling centrifugal pumps would like to secure other lines in water works field. Covers eastern Pennsylvania, south Jersey and Delaware.

Established distributor having large warehouse facilities, serving Florida and adjacent territory would like to add to lines now represented, such as road building material and equipment, industrial equipment and contractors' equipment and materials and diesel engines.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Manufacturer's representative, with warehouse facilities available, would like to secure additional lines in water works and sewerage and general contracting fields. Covers Houston and San Antonio territory.

Manufacturer's representative with 25 years sales experience, conversant with all types of pumps and their field, desires agency for either New York or export territory, or both.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Equipment distributor located in Michigan desires to add two or three good lines to serve territory in southeastern part of state.

Machinery distributor established in Porto Rico and Santo Domingo would be pleased to make arrangements to take on new lines in these territories.

A Michigan distributor, with many year's experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing incrased facilities in this region.

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Representatives Wanted

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of paving expansion joints is seeking distributors and manufacturers' agents in good, unassigned territory.

Manufacturer of air compressors and contractors' tools has number of desirable territories open. Full co-operation will be extended to distributors.

Manufacturer of contractors and builders levels and transits is seeking district sales manager. Exclusive contract given. Excellent territory still available. Backed by national advertising.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

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One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

REFUSE DISPOSAL

THE City of Liverpool, England, uses a "Caterpillar" Tractor and modern bulldozer and scraper on one of its garbage dumps—layers of refuse are covered by layers of earth. The "Caterpillar" and scraper excavate the earth, the same tractor bulldozes the great piles of waste and then spreads the earth. Traction and power conquer a hard job—"Caterpillar" Tractors serve another city!

Prices—f. o. b. Peoria, Illinois

TEN	$1100	TWENTY . .	$1900
FIFTEEN . .	$1450	THIRTY . .	$2375
SIXTY . . .	$4175		

Caterpillar Tractor Co.

PEORIA, ILL. *and* SAN LEANDRO, CALIF., U. S. A.

Track-type Tractors Combines Road Machinery

(There's a "Caterpillar" Dealer Near You)

CATERPILLAR
REG. U.S. PAT. OFF.
TRACTOR

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Dr. James Aston Awarded Robt. W. Hunt Medal

James Aston, Consulting Metallurgist for the A. M. Byers Company, Pittsburgh, Director of the Department of Mining and Metallurgy, Carnegie Institute of Technology and inventor of the Byers' New Process for manufacturing wrought iron, has been awarded the Robert W. Hunt Medal.

This award is a high honor in the metallurgical field and has been made only three times in the last ten years. The American Institute of Mining and Metallurgical Engineers is said to base the award of the medal on the practical rather than the theoretical side of the best paper presented, dealing with a development in the iron and steel industry.

Dr. Aston was born in England in 1876. His early education was received in Milwaukee. In 1898 he graduated from the University of Wisconsin with a B. S. Degree in Electrical Engineering.

In 1908 he returned to the University of Wisconsin for further research in metallurgy and a year later became an instructor in the department of metallurgy. Following four years' work at the University he took his degree as Chemical Engineer and went to the University of Cincinnati to do analytical metallurgy. After four years at the University of Cincinnati, Dr. Aston went with the Bureau of Mines in Pittsburgh as a specialist in corrosion problems. In 1915 he joined the A. M. Byers Company as Chief Metallurgist.

In addition to being a member of the American and British Iron and Steel Institutes, Dr. Aston is a member of the American Electro-Chemical Society, the American Institute of Mining and Metallurgical Engineers, the American Society for Testing Materials, the American Society for Steel Treating and the Engineers' Society of Western Pennsylvania.

Dr. James Aston

A. J. Duaei Joins W-K-M Company

W-K-M Company, Inc., manufacturers of oil field, pipe-line, and industrial equipment, announce the appointment of Mr. Alexander J. Duaei as Manager of Sales, Western Territory. Offices have been established by the company at 205 West Wacker Drive, Chicago.

Alexander J. Duaei, Manager of Sales, Western Territory, W-K-M Co.

Prior to associating himself with W-K-M Company, Mr. Duaei was for eleven years connected with the Johns-Manville Company, seven years of which he was manager of the public utilities division of that organization.

During Mr. Duaei's years of connection with Johns-Manville he has formed many friendships among executives in the electric light, power, and gas companies throughout the United States.

His broad knowledge of pipe line materials and particularly his knowledge of underground construction, fit him in an exceptional manner for his new association with W-K-M Company.

Mr. Duaei was born in Amsterdam, Holland, and was educated in New York, and European universities.

Timken Elects Officials

At the annual shareholders meeting of The Timken Roller Bearing Company recently directors elected were H. H. Timken, J. G. Obermier, M. T. Lothrop, J. W. Spray, Henry H. Timken, Jr., of Canton; W. R. Timken of New York and A. C. Ernst of Cleveland. Officers elected at the directors meeting were H. H. Timken, Chairman; M. T. Lothrop, President; W. R. Timken, J. G. Obermier, J. W. Spray, H. J. Porter, T. V. Buckwalter, L. M. Klinedinst, Vice Presidents; R. C. Brower, Secretary-Treasurer; J. A. Riley, Assistant Treasurer; F. F. Tudor, Assistant Secretary.

Linde Products to Participate in Foundrymen's Exposition

The Linde Air Products Company and Associated Companies will have a display at the annual convention and exhibit of the American Foundrymen's Association, Public Auditorium, Cleveland, O., May 12 to 16, inclusive. The Linde display will place emphasis on the various applications of the oxy-acetylene process in modern foundry practice.

Some of the welding equipment featured at the Linde booth includes a 20-cylinder wall type oxygen manifold and an Oxweld 300-lb medium pressure acetylene generator. A complete line of Oxweld and Prest-O-Weld welding and cutting blowpipes will also be on display, together with exhibits of Union Carbide, Carbic, Prest-O-Lite, Acetylene and Linde Oxygen. A cordial invitation is extended to visit the booths.

W-K-M Pays 8 Per Cent for First Quarter

On April 8 W-K-M Co., Inc., of Houston, Tex., manufacturers of industrial, oilfield, pipe line, tractor and public utilities equipment, mailed out, as of March 31, 8 per cent interest earnings on their recent issue of preferred stock. As announced in the early part of January, W-K-M capital stock has been increased by $400,000. The company reports very good business for the first three months of the year, with bright prospects for the remaining nine months, especially in the export field.

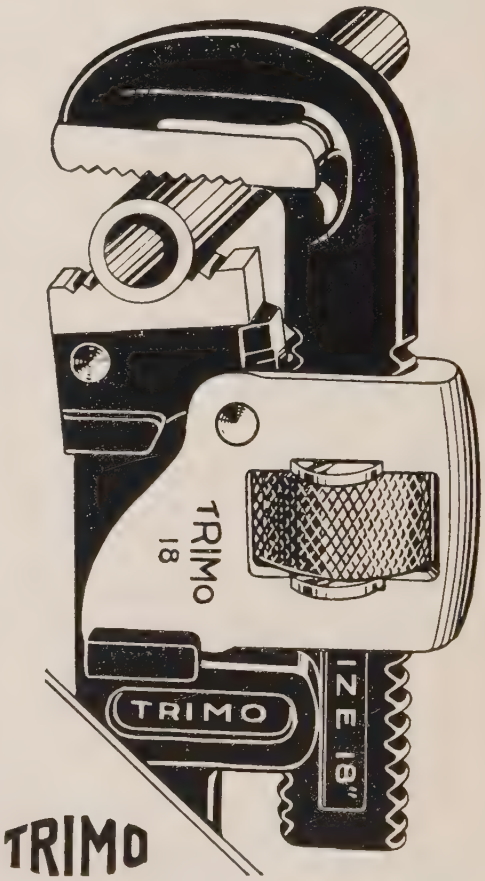
Budd Wheel Company, of Detroit, reports that service and replacement sales for February were 10.6 per cent above those for the corresponding month in 1929, and that the large volume of unfilled orders with which the month of March started indicates unprecedented earnings in this department.

Let the Oil Worker Help You to Choose

ANY official whose duty it is to select pipe wrenches or chain wrenches can find valuable guidance in the experience and choice of the oil worker.

For the oil fields are the proving ground of pipe wrenches. Nowhere else must tools measure up to such standards of service, safety and strength. Nowhere else is the work more strenuous and punishing.

And the oil man's choice today, as it has been for years, is All-Steel TRIMO.



TRIMO
Pipe Wrench

All Steel for Strength
Handle Drop Forged Not Cast

Made by **Trimont Mfg. Co., Inc.,** Roxbury (Boston), Mass.

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Bacteriologist would like to make connection with manufacturer for such work, or as assistant chemist.

Water Works equipment distributor, covering northeastern Indiana, would like to secure represenation of a line of chlorinators.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

A Michigan distributor, with many year's experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing incrased facilities in this region.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Manufacturer's representative with 25 years sales experience, conversant with all types of pumps and their field, desires agency for either New York or export territory, or both.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Manufacturer's representative, with warehouse facilities available, would like to secure additional lines in water works and sewerage and general contracting fields. Covers Houston and San Antonio territory.

Representatives Wanted

Manufacturer of metal tie and spacer wishes to establish distributing points throughout the country.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

Distributor of building specialties covering a territory of 100 mile radius from Chicago is equipped to represent additional lines.

Manufacturer's agent with 20 years' experience desires agencies for any type of building specialties or contractors' machinery except mixers. Familiar with all types of contractors' machinery. Could act as sales manager for Atlantic Coast line with dealers.

Manufacturer of air compressors and contractors' tools has number of desirable territories open. Full co-operation will be extended to distributors.

Manufacturer of contractors and builders levels and transits is seeking district sales manager. Exclusive contract given. Excellent territory still available. Backed by national advertising.

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One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

Manufacturer of centrifugal pumps for water works, sewage plants, sand and dredging plants, process industry, contractors, etc., desires to secure additional representation. Attractive territory available.

THE MOST IMPORTANT INGREDIENT IN YOUR PIPE COATING IS

EXPERIENCE

The best solution to any of the problems that come up in the business of coating pipes is knowledge. Robertson has the knowledge. The H. H. Robertson Co. is the world's largest producer of special asphalts. It has made investigations in the action of soils on coating materials. It can determine the exact combination of asphaltic bases that are best calculated to protect your pipe under any given set of conditions . . . and it can produce exactly that combination.

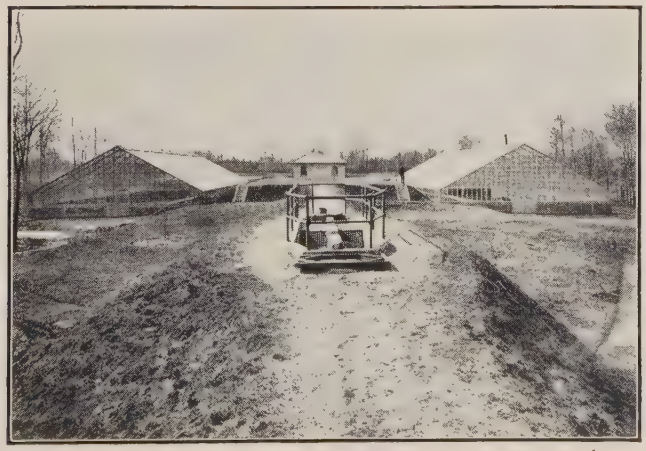
Specify Robertson coatings on your pipes.

H. H. ROBERTSON CO.,
PITTSBURGH, PA.

ROBERTSON
HAS THE EXPERIENCE

Leading Communities Are Solving Sludge Bed Problems with KINGS

By doubling (and even trebling!) the capacity of sludge beds originally uncovered, King Enclosures are affording an economical solution to one of the big problems of modern day sewage disposal. . . . But this is not all! Urban localities demand an attractive, inoffensive plant—one which will fit in with pleasant surroundings. King Enclosures fulfill this requirement. . . . Designed by experienced engineers, rigidly built by a veteran organization, King Enclosures are today efficiently serving prominent communities all over the country. . . .



Let us send all the facts!

KING CONSTRUCTION COMPANY
533 Wheatfield Street
North Tonawanda, N. Y.

New York City · Philadelphia, Pa. · Boston, Mass.
Scranton, Pa. · Toledo, Ohio
Schenectady, N. Y. · Bridgeport, Conn.

Illustration shows the two 48 ft. x 97 ft. King Enclosures erected for Boroughs of Bergenfield and Dumont at Dumont, N. J. Engineer, Thos. F. Bowe.

Framework: copper-bearing flat steel side posts and flat steel rafters spaced on 8 ft. 5 in. centers; steel trussing; steel gable rafters.

Woodwork: sash bars, ridge, ridge caps, rafter caps, gable rafters, sash doors, door frames—all manufactured from straight-grained, clear heart, air-dried California redwood.

Ventilation: both sides of the ridges and the sides. This gives a positive control of odors.

Tagliabue Acquires Large Property

The C. J. Tagliabue Mfg. Co., of Brooklyn, N. Y., well known maker of instruments, announced the acquisition of the American Tobacco Co. property on Park Ave., extending from Nostrand Ave. to Sanford St. in Brooklyn.

New Home of C. J. Talgiabue Mfg. Co., Brooklyn

The Tagliabue company has been industrially prominent in Brooklyn for many years as makers of TAG industrial and laboratory instruments, such as indicating, recording and controlling instruments for temperature, pressure, humidity, time, condensation and liquid level, laboratory and industrial thermometers, hydrometers and oil testing instruments.

The company enlarges to more than double its present facilities in its projected removal to Park Ave. The new building, a model of the latest industrial construction, will be occupied about the first of July. It is a five-story, basement and pent house, modern concrete, fireproof structure covering the entire block front on Park Ave., from Nostrand Ave. to Sanford St. The plot measures 200x234 ft. and the building provides approximately 300,000 sq. ft. of working floor space with lofty 14-ft. ceilings and modern steel sash, making it unusually light.

Located on the third floor, the executive offices will command a centralized approach to every department. A large reception room and show room are provided on this floor, where permanent exhibits of the products will be on display.

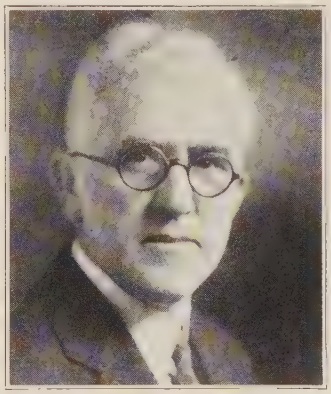
Manitowoc Engineering Adds New Distributors

The following distributors will handle Moore speedcranes, shovels, draglines and trenchoes in their various territories, for the Manitowoc Engineering Works, whose plant is located at Manitowoc, Wis.:

Edgerton & Sons Co., 585 Hosatonic Ave., Bridgeport, Conn.; Hudson Valley Welding Co., 7 Buckingham Ave., Poughkeepsie, N. Y.; W. A. Ward, Hillsdale, N. Y.; James Beale, Jr., Box 445, Sound Berch, Conn.; Ilium Truck & Equipment Co., Inc., 2 Oakwood Ave., Troy, N. Y.; Contractors Machinery Co., Kansas City, Mo.; J. B. Harbison Equipment Co., Little Rock, Ark.; Northfield Iron Co., Northfield, Minn.; J. C. McDonald, 2104 Webster St., Omaha, Neb.; Contractors Machinery & Supply Co., 318 Penn Ave., Pittsburgh, Pa.; LaLance Equipment Co., Huntington, W. Va.; Richmond Machinery Co., Richmond, Va.; J. W. Hodge, 1334 N. Highland Ave., Atlanta, Ga.; Harvard Turnbull & Co., Excelsior Life Building, Toronto, Ont.

Kanitz Made General Sales Manager for Continental Motors Corporation

W. R. Angell, President of Continental Motors Corporation announces the



W. R. Angell

appointment of Louis J. Kanitz as General Sales Manager of the organization. Mr. Kanitz joined the Continental Motors Corporation in February 1920 after resigning his commission as Lieut. Commander in the United States Navy.

Louis J. Kanitz

For the past three years he has been in charge of the industrial engine division of the company. Mr. Kanitz was instrumental in the formation of that branch of Continental's activities.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

Of Water Works and Sewerage, published monthly at Chicago, Illinois, for April 1, 1930.

State of Illinois } ss.
County of Cook }

Before me, a notary public in and for the State and county aforesaid, personally appeared E. S. Gillette, who, having been duly sworn according to law, deposes and says that he is the business manager of the Water Works and Sewerage and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Gillette Publishing Company, 221 E. 20th St., Chicago, Ill. Editor, H. P. Gillette, 221 E. 20th St., Chicago, Ill. Managing Editor, C. T. Murray, 221 E. 20th St., Chicago, Ill. Business Manager, E. S. Gillette, 221 E. 20th St., Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Gillette Publishing Company, 221 E. 20th St., Chicago, Ill.; H. P. Gillette, 221 E. 20th St., Chicago, Ill.; E. S. Gillette, 221 E. 20th St., Chicago, Ill.; Mrs. R. W. Hume, 303 S. Stone Ave., LaGrange, Ill.; Winifred Gillette, 1125 Oak Grove Ave., San Marino, Calif.; Commonwealth Title Insurance & Trust Co., Chestnut and 12th Sts., Philadelphia, Pa.; Louise Forsythe, 13 E. Windermere Terrace, Lansdowne, Pa.; LaVerne Louer Hellyer, Ambassador Hotel, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is: (This information is required from daily publications only.)

E. S. GILLETTE.
(Signature of business manager.)

Sworn to and subscribed before me this 21st day of March, 1930.

(Seal) KITTIE C. WOULFE,
Notary Public.
(My commission expires Feb. 8, 1934.)

THE INCREASING USE OF THE TELEPHONE REQUIRES THE EXPENDITURE OF HUNDREDS OF MILLIONS ANNUALLY FOR EXTENSIONS AND IMPROVEMENTS

It keeps faith with your needs

An Advertisement of the American Telephone and Telegraph Company

You have found a constantly growing use for the telephone. You have learned its value in business. You have found it helpful in keeping contact with family and friends. Its increasing use has given the telephone its humanly important place in modern life and requires the expenditure of hundreds of millions annually for extensions and improvements.

In 1929 the Bell System's additions, betterments and replacements, with new manufacturing facilities, meant an expenditure of 633 million dollars. During 1930 this total will be more than 700 millions.

Definite improvements in your service result from a program of this size and kind. They start with the average time required to put in your telephone—which in five years has been cut nearly in half. They range through the other branches of your service, even to calls for distant points—so that all but a very few of them are now completed while you remain at the telephone.

In order to give the most effective, as well as the most economical service, the operation of the Bell System is carried on by 24 Associated Companies, each attuned to the part of the country it serves.

The Bell Laboratories are constantly engaged in telephone research. The Western Electric Company is manufacturing the precision equipment needed by the System. The staff of the American Telephone and Telegraph Company is developing better methods for the use of the operating companies. It is the aim of the Bell System continually to furnish a better telephone service for the nation.

H. W. FORD
District Manager
Pittsburgh-Des Moines Steel Co.
New York

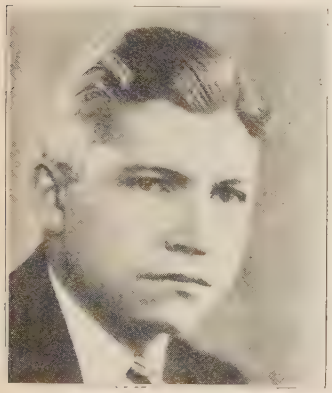
J. E. O'LEARY
Genl. Sales Manager
Pittsburgh-Des Moines Steel Co.
Pittsburgh, Pa.

O. D. DeHART
District Manager
Pittsburgh-Des Moines Steel Co.
Dallas, Texas

H. D. FOWLER
District Manager
Pittsburgh-Des Moines Steel Co.
Seattle, Wash.

H. M. HOWARD
District Manager
Pittsburgh-Des Moines Steel Co.
Atlanta, Ga.

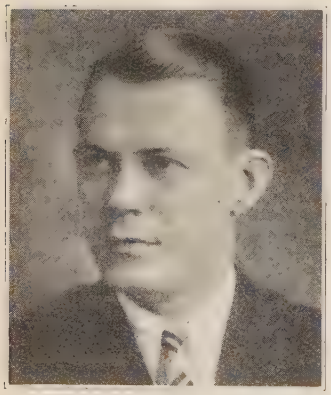
MAXWELL WHITACRE
Mgr. Chicago Office
Pittsburgh-Des Moines Steel Co.
Chicago



E. W. THOMAS, JR.
Chicago Dist. Sales Representative
Reading Iron Company
Reading, Pa.

H. F. MATTERN
Genl. Sales Mgr. New York Office
Reading Iron Company
Reading, Pa.

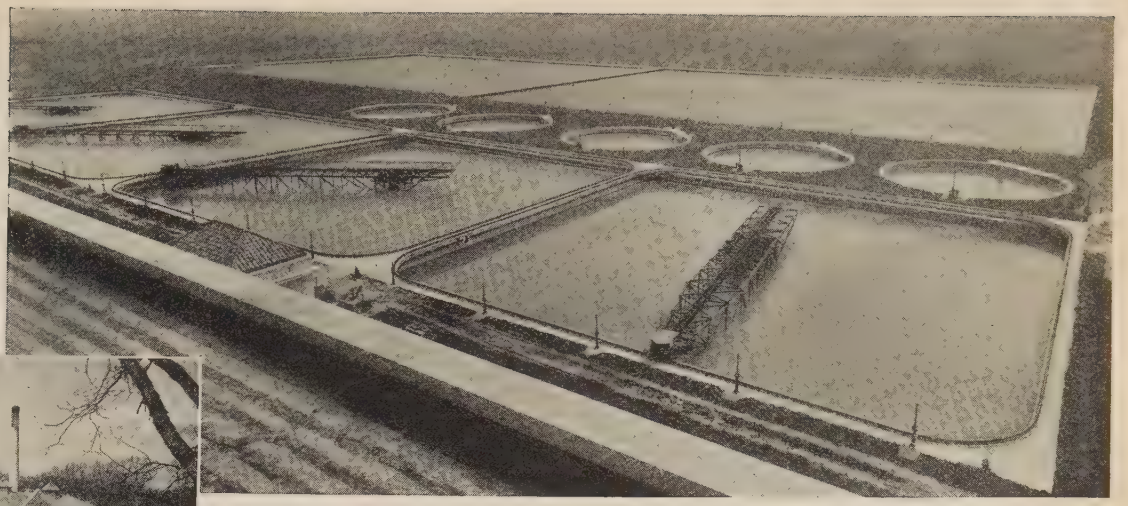
H. S. CARLAND
New York Dist. Sales Representative
Reading Iron Company
Reading, Pa.



R. B. ANDREWS
Rome Brass & Copper Co., Div.
Revere Copper & Brass, Inc.
Rome, N. Y.

E. I. VAN DOREN
The E. I. Van Doren Companies
Rep. Yeomans Bros. & S. E. T. Valve
Troy, N. Y.

W. A. STANCER
Sales Manager
Whitney Engineering Co.
Tacoma, Wash.



Four Dorr Traction Clarifiers in the Howard Bend Plant, St. Louis.
L. A. Day, Water Commissioner, E. E. Easterday, Designing Engineer

Mamaroneck, N. Y., Alexander Potter, Cons. Engr.

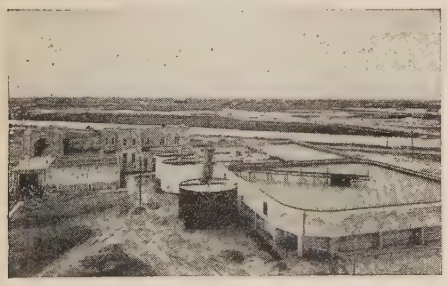
At the A. W. W. A. Convention—

You Will See Dorr Clarifiers in St. Louis' New Water Treatment Plant

Boca Raton, Fla., H. S. R. McCurdy, Cons. Engr.

IF you are planning on attending the convention of the American Water Works Association in St. Louis, you will undoubtedly see the Dorr Traction Clarifiers, which are used for primary and secondary sedimentation, in the Howard Bend water treatment plant.

However, it is not necessary to go to St. Louis to see these continuously cleaned sedimentation basins. Visit any recently built or currently building water treatment plant in the U. S. or Canada and you are almost sure to find Dorr Clarifiers on the job. The small illustrations show some of these installations.



Miami, Fla., Alvord, Burdick & Howson, Cons. Engrs.

Ask our nearest office for a copy of the new edition of our booklet, "Moddern Sanitary Engineering Practice"

DORRCO

THE DORR COMPANY

ENGINEERS

247 PARK AVENUE NEW YORK CITY

INVESTIGATION TESTS DESIGN EQUIPMENT

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1009 17th Street

CHICAGO, ILL.
333 North Michigan Avenue

LOS ANGELES, CAL.
108 West 6th Street

WILKES BARRE, PA.
Miners Bank Building

ATLANTA, GA.
1503 Candler Building

TORONTO, ONT.
330 Bay St.

MELBOURNE, AUSTRALIA
Crossle & Duff Pty., Ltd., 360 Collins Street

TOKYO, JAPAN
Andrews & George Co., Inc., Central P. O. Box F-23

LONDON
The Dorr Company, Ltd.
Abford House, Wilon Rd., S. W. 1

BERLIN
Dorr Gesellschaft m. b. H.
Kielganstr, 1 W. 62

PARIS
Societe Dorr et Cie
26 Rue de la Pepiniere

JOHANNESBURG, S. A.
E. L. Bateman
Locarno House.

C. F. WALLACE
Vice-President
Wallace & Tiernan Co., Inc.
Newark, N. J.

M. F. TIERNAN
President
Wallace & Tiernan Co., Inc.
Newark, N. J.

A. J. DUAEI
Western Sales Manager
W-K-M Company
Houston, Texas

R. R. NORRIS
Mgr. Sales Industrial Div.
W-K-M Company
Houston, Texas

E. L. SCHWANHAUSSER
Mgr. Buffalo Works
Worthington Pump & Machinery Corp.
New York

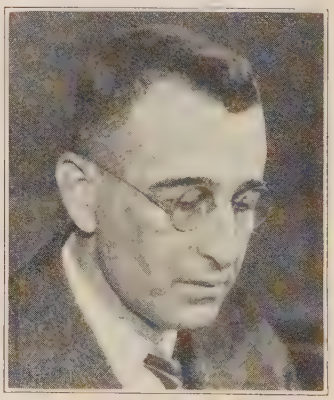
S. NICKERSON
Meter Representative
Worthington Pump & Machinery Corp.
Kansas City, Mo.

H. J. MEEKER
Manager, Public Works
Centrifugal Sales Dept.
Worthington Pump & Machinery Corp.

GEORGE H. CARR
Meter Representative
Worthington Pump & Machinery Corp.
Chicago, Ill.

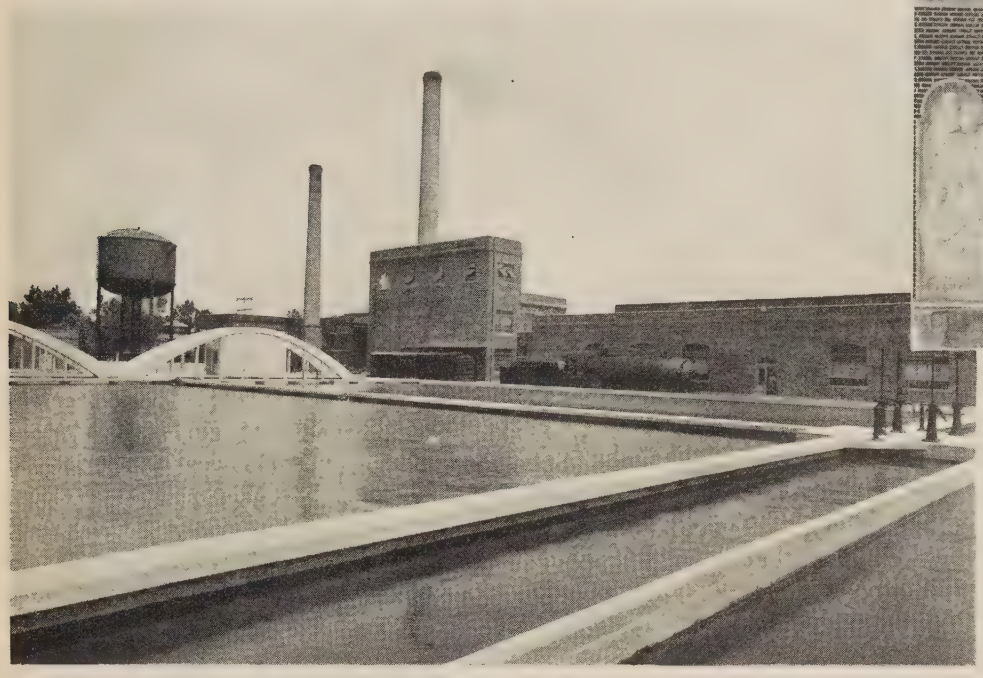
H. P. MATTE
Manager, Meter Division
Worthington Pump & Machinery Corp.
Harrison, N. J.

R. D. HALL
Manager, Water Works Sales
Worthington Pump & Machinery Corp.
Harrison, N. J.



A. H. BORCHARDT
Acting Mgr., Centrifugal Sales Div.
Worthington Pump & Machinery Corp.
Harrison, N. J.

Plan Now To Give Your City Soft Water



Architectural beauty typifies benefits brought by pure, soft water to the health and happiness of citizens of Springfield, Illinois. This waterworks plant is the first and largest in Illinois to do, in one operation, these four things: 1. Filter the water; 2. Soften the water; 3. Remove the iron; 4. Recarbonate the water.

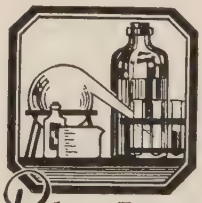
Plant designed by Burns & McDonnell Engineering Co., Consulting Engineers, Kansas City-Los Angeles

OF all municipal improvements none brings greater benefits--both from the standpoint of a city's investment and the health and happiness of its citizens--than plenty of pure, soft water.

The benefits of soft water are community-wide. The rapid increase in the number of municipal water softening plants is evidence of the wide recognition among superintendents, city officials and the public, that soft water is a necessary civic asset.

Nothing arouses civic pride like a supply of clear, sparkling water--free from odors, taste and bacteria. It is additional good policy for the water board to typify these desirable characteristics by erecting attractive as well as practical structures.

Cities operating filtration plants where the water is hard, would profit greatly by adding a softening plant at slight extra cost. Filtration plants now being designed should provide for softening as well as for purification. If the carbonates are high enough to justify a lime treatment, the lime will serve as a purifying as well as a softening agent, for lime is a most effective germicide.



Rely on LIME *-tested by time*

When soft water is available, cities can attract new industries by assuring them at least 10% annual reduction in operating costs.

For every municipal dollar invested for water softening, citizens save many. The annual saving in soap alone will average three times the annual cost of softening the water with lime. Additional savings would be: decreased fuel bills of 5 to 10% due to scale-free water; reduced repairs to heater coils and replacement of plumbing fixtures; lowered laundry bills and cleaning costs for removing iron stains.

The National Lime Association offers its cooperation in furnishing interested officials full information.

NATIONAL LIME ASSOCIATION

An organization of leading lime manufacturers formed to encourage a better appreciation of the economic value of lime in all its uses.

711 PHILLIPS BUILDING « WASHINGTON, D.C.

148-A

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Badger Meter Announces a Record Year at Sales Conference

The accomplishments of the Badger Meter Manufacturing Company during 1929 were the keynotes of the annual sales meeting held recently in the home office at Milwaukee, Wis. Officials of the company pointed out the strides made during the past year, and stated that 1929 was the biggest in the history of the company, which is now in its 26th year. This splendid showing was attributed to the increased manufacturing space and facilities, additional sales representatives, and a more complete line of water meters.

During the last few years, the company made an addition to the plant which covered a half block square, giving it an increased floor space of 45,000 sq. ft. in the manufacturing and assembling buildings. Besides this addition, a new brass foundry was constructed, having 15,000 sq. ft. of floor space and equipped in the newest and latest type of machines.

New models have been added to the Badger line during the past year, standards of the American Water Works and New England Water Works Associations have been fully complied with in redesigning, and all changes were made to increase efficiency and serviceability, details concerning which were pointed out and discussed at the meeting.

It was reported that the company's engineering staff and research laboratory staff have been added to considerably and a definite program has been planned to keep the products abreast of the requirements of the field, and to introduce such new meters as are necessary from time to time to increase meter efficiency. Two developments of the past year were an automatic batch water meter for accurately measuring water on central concrete mixing plants, and a companion concrete batch mix meter for installation on portable concrete mixers. The industrial meter division has been expanded, and an electric alarm register set-up for practical application for measuring equipment as applied to water softeners has also been developed.

Expect Ex-President Coolidge at Fairbanks-Morse Pageant

The hundredth anniversary of the founding of Fairbanks-Morse & Company will be commemorated in a three-day celebration starting on July 4th in the historical city of St. Johnsbury, Vt.

Ex-President Coolidge was at one time a student at the St. Johnsbury Academy, which was sponsored and supported by Thaddeus Fairbanks, and, according to announcement, it is expected that he and Mrs. Coolidge will be guests of honor at the celebration.

Thaddeus Fairbanks, known as the "father of modern weighing," invented the platform scales one hundred years ago, and with his brothers started their manufacturing business with an investment of $4,000.

The principal feature of the program, as announced, will be an historical pageant depicting the progress during the last century in the evolution of the modern weighing machine and its influence upon human welfare and world commerce.

Tube-Turns Appoints Distributors

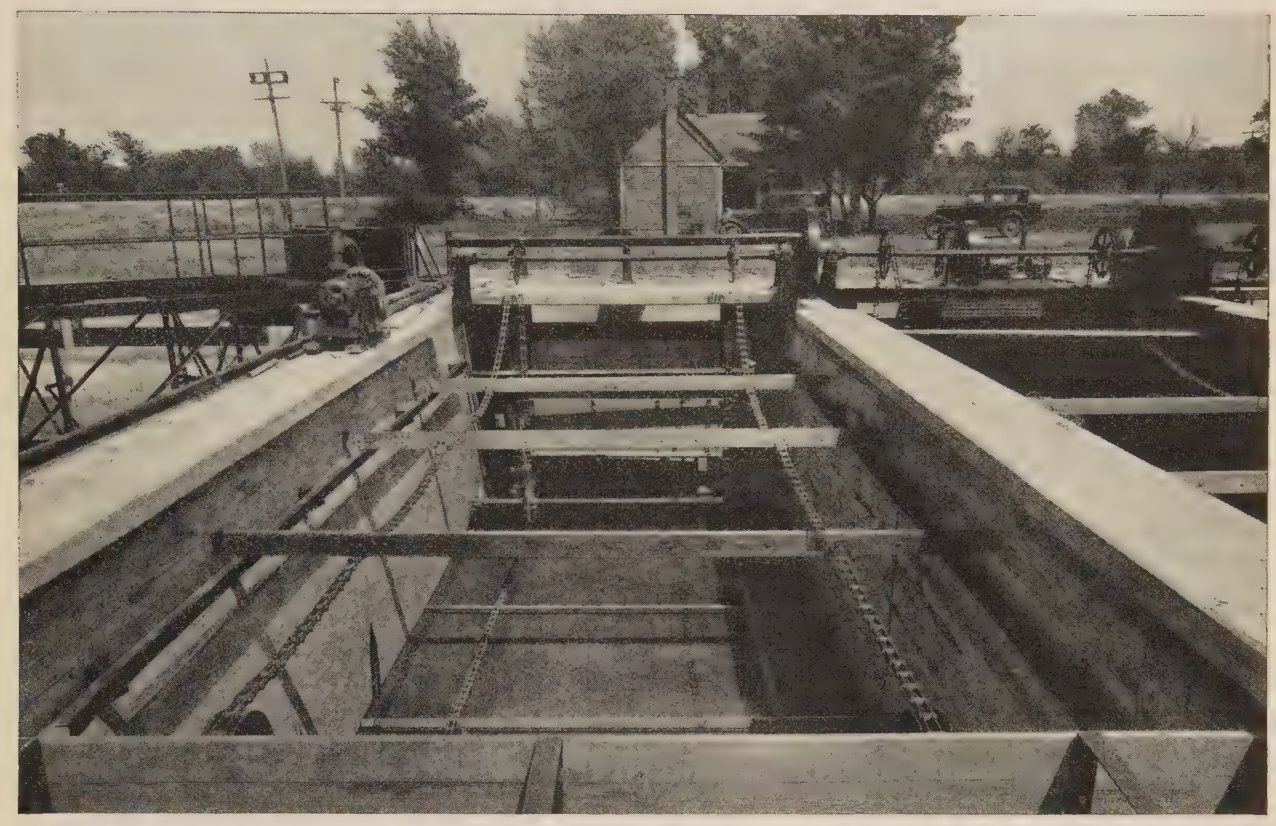
Appointment of new distributors is announced by Tube-Turns, Inc., Louisville, Ky., manufacturers and marketers of seamless, short radius forged fittings for pipe welding, as follows:

The Grinnell Company, at Charlotte, N. C., for North and South Carolina and Georgia; Ebbert & Kirkman Company, Inc., of Birmingham, Ala., for Alabama; the B. Hoffmann Manufacturing Company, of Milwaukee, for Milwaukee and adjacent territory; the United Pipe & Supply Company, of Charleston, W. Va., for Charleston and adjacent territory; the Vulcan Copper & Supply Company of Cincinnati, for Cincinnati and adjacent territory, and Hedley & Voisinet of Buffalo, for Buffalo and surrounding territory.

The Paradon Manufacturing Co. of Arlington, N. J., announces the appointment of the Sanitary Appliance Co., Inc., 308 Hughes St., Houston, Tex., as representatives for the sale and service of Paradon chlorinators and allied products in the state of Texas.

Representatives and Officials of the Badger Meter Manufacturing Company, Milwaukee, Wis.

Link-Belt STRAIGHTLINE Collectors for Sludge, Grit and Scum



Springfield, Ill. Showing two of three Primary Settling Tanks with Straightline Collectors, at the Activated Sludge Plant.

STRAIGHTLINE collection, with its straight working pulls, means that the major stresses are tensile stresses. Tension members may have very large factors of safety without being unwieldy, and large factors of safety insure uninterrupted operation through a wide range of conditions.

STRAIGHTLINE operation is of proved reliability. Link-Belt units of this type have been in operation for more than a decade in coal-washers where the loads are heavy and the materials abrasive—the original chains are still in use! Modern Link-Belt units will last even longer. Designs have been improved, and important new features added so that the Link-Belt Company feels every confidence in offering STRAIGHTLINE to the Sanitary Engineering profession.

Turn to Link-Belt for sewage treatment plant equipment — Collectors, Fine Screens, Mechanically Cleaned Bar Screens and Mechanical Aerators. Send for new Book No. 642.

LINK-BELT COMPANY

PHILADELPHIA, 2045 W. Hunting Park Ave. CHICAGO, 300 W. Pershing Road

3905

LINK-BELT

SEWAGE TREATMENT PLANT EQUIPMENT

How Times Have Changed!

In speaking of the early days of the McWane family in the foundry business, J. R. McWane, now president of the McWane Cast Iron Pipe Company of Birmingham, and of the Pacific States Cast Iron Pipe Company of Provo, Utah, relates:

"When I was a small boy, at Wytheville, Va., my father gratified the ambition he had always cherished to go into the foundry business. He had $300 in cash with which he purchased a second-hand boiler for a cupola, and a second-hand horse power to drive the blower. He made his own blower, using wood for the shell and sheet iron for blades. It made as much noise as a threshing machine.

"A small blacksmith shop in our back yard was converted into a foundry. Every Saturday afternoon Bill Holly, a negro teamster, would bring his two horses and a crippled mule and hitch up to the horse power for the weekly 'heat.' On the signal that all was ready, Bill would mount the platform in the center, crack his whip, and the noise would start. The tonnage made was usually about 1,000 lb., mostly plow castings.

"The excitement of the melt lasted about two hours. Father, the patternmaker, carried one end of the ladle shank, and my oldest brother, the molder, carried the other end. No payroll and no overhead, consequently success!

"Later father bought a small engine and a little machinery and moved uptown to a new location. Here I learned the molder's trade and acquired my love for the foundry business. My father taught me, by precept and example, to depend on my own resources; and for this as well as other lessons taught by him, I shall always be most grateful."

The real beginning of the McWane Cast Iron Pipe Company, which has recently completed the handsome new office building shown on this page, was in 1921 when, under the direction of its president, J. R. McWane, cast iron pipe was manufactured in very small sizes in the rented foundry pictured in the inset of the view of the Birmingham plant. J. D. Sample was then vice-president, general manager, secretary and treasurer.

The company attributes its success and rapid growth to the many increasing demands for small cast iron pipe in which it has specialized. In 1922 A. T. McWane, younger brother of the president, joined the company as secretary-treasurer, and soon after that date a new foundry was built especially for the McWane processes of casting pipe in small sizes and horizontally in green sand molds with green sand cores.

With the growth of the business, the two salesmen, one located in Philadelphia and one in Los Angeles, had to have reinforcements, and offices were opened in Dallas and in Chicago. But, the high freight rates to the Rocky Mountain region and west, made shipments from Birmingham well-nigh prohibitive, so another cast iron foundry seemed the answer to this marketing problem. This was the reason for the organization of the Pacific States Cast Iron Pipe Company, jointly with the Columbia Steel Corporation, which was already established at Provo, Utah. This step was taken in 1926, resulting in the opening of offices in San Francisco, Portland, Salt Lake City and Denver.

The next important step in the development of this organization was to find a way to turn the hand processes in use into mechanical processes, in the words of one of the officials it was: "mechanize or paralyze." With necessity driving, methods were evolved for making their cast iron pipe by mechanical means instead of by hand, although holding to the same basic principles, and now, it is said, "a literal torrent of pipe pours out from the finishing departments of the plant, day and night.

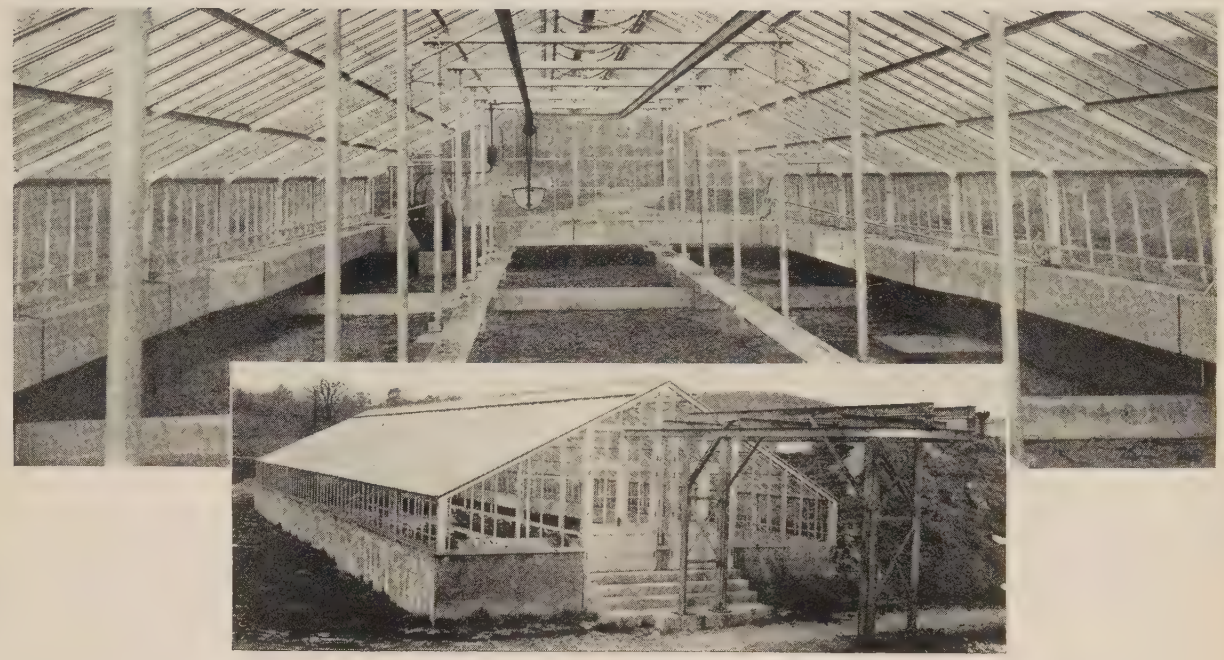
In 1929 the Columbia Steel Corporation was purchased by the United States Steel Corporation and a deal resulted by which the Pacific States Cast Iron Pipe Company came wholly under McWane ownership.

Provo, Utah, Plant of Pacific States Cast Iron Pipe Co., Where McWane Pipe for the Territory West of the Rockies Is Produced

New Office Building of McWane Cast Iron Pipe Co., 12th Ave. and Vanderbilt Rd., Birmingham, Ala.

View of Birmingham Plant of McWane Cast Iron Pipe, with Inset Showing Plant in 1922

Master Construction Glass-Overs for Sludge Beds



The J. N. Chester Engineers, Pittsburgh, Pa.

Facts Concerning The Disposal System At New Lexington, Ohio

The plant is designed to treat an average flow of 500,000 gallons per day, serving a population of 5000. In addition to the one Lord & Burnham Sludge Bed Glass Over for speeding up the drying of the sludge, the equipment consists of the following:

(1) An automatic sewage pumping station.
(2) Coarse Screens.
(3) 4 Imhoff tanks
(4) Dosing tank.
(5) A trickling filter.
(6) A humus tank equipped with Dorr Thickener.
(7) A laboratory and general service building.

The sewer system is strictly sanitary, and consists of more than 20 miles of sewers, ranging in size from 8″ to 18″, all constructed according to the engineers' plans and specifications, simultaneously with the construction of the sewage disposal plant.

The city has passed a sewer rental law whereby each household, industry, and public building, is charged for the services rendered by the sewerage system and sewage disposal plant, thus providing operating funds for this purpose.

The Glass-Over itself, is the latest in design and construction, giving quick drying results and insuring long life to the structure. No other construction has the same proven practicalness and endurance. Send for full particulars.

Lord & Burnham Co.

Sludge Bed Glass-Overs

Graybar Building
New York City

208 South LaSalle Street
Chicago, Ill.

Harbor Commission Building
Toronto, Canada

Branch Offices: Boston, Philadelphia, Irvington, Albany, Denver, Detroit, Cleveland, Kansas City, Buffalo, Greensboro, St. Louis, Montreal, St. Catharines

Although the company is still in its first decade, the second generation is represented by Mr. William McWane, son of the president, who serves as his father's assistant and as secretary of the organization. It is said that courage to disregard precedent, along with a policy of bringing in new blood from outside the cast iron pipe field, which "in its ignorance, did not know that 'it couldn't be done'" contributed to the success of the industry.

American Rolling Mill Sets New Safety Record

The Middletown Works of The American Rolling Mill Co., of Middletown, O., has announced a new Armco plant safety record by completing 1,300,000 man-hours without lost time because of accident.

In 1929, it is stated, that the Middletown plant had thirty-two accidents for the period to date for which they now have two. During the same period in 1929 the company as a whole had eighty-six accidents, which for the 1930 period was reduced to twenty-six.

The record which the Middletown plant holds started Feb. 21, 1930. The Middletown plant includes all operations from open hearth to shipping of the finished sheet.

A new company record was announced recently when the entire organization went eleven days without a lost time accident. The previous record was ten days.

Newby Made Western Manager for Hyatt Roller Bearing

Announcement has been made of the appointment of C. L. Newby as manager of the western division of The Hyatt Roller Bearing Co. of Newark, N. J. His headquarters will continue to be in Chicago, where he formerly served as assistant manager.

Mr. Newby has been associated with the Hyatt company since 1918 as sales engineer on general industrial, oil field, railroad and farm machinery application.

E. A. Doyle Elected Head of American Welding Society

E. A. Doyle, consulting engineer of the Linde Air Products Company, was elected president of the American Welding Society at the annual meeting of the society, held recently.

Lincoln Electric Announces Personnel Changes

Three members of the manufacturing district of the Lincoln Electric Company, Cleveland, O., have been transferred to the welder service division, according to announcement issued by the company.

Mr. John C. Ardagh will be established at the Chicago headquarters in the Monadnock Building, Chicago. Mr. R. A. Kyle has been sent to the New York district, and will be located at 136 Liberty St., New York City. Mr. Robert Newton has gone to Cleveland, and will have his headquarters at the Cleveland factory.

Phoenix Mfg. Co. Purchases Plant from Graver Corp.

In a recent announcement, Mr. Edward N. Gosselin, president of the Phoenix Manufacturing Company of Joliet, states that the steel tank, water treating and steel plate construction business of the Graver Corporation, including the East Chicago plant, has been taken over as a subsidiary company of Phoenix and will be operated as Graver Tank & Manufacturing Corporation. It is stated that plans for addition and improvements are now being made to make the plant one of the most modern in the country.

Branch offices of the new company will be maintained in Chicago, New York, Dallas, St. Louis, San Francisco and other large centers. The general offices will be located at East Chicago, Ind. The officers are: Edward N. Gosselin, president; F. C. Everitt, vice-president and general manager; R. E. Meyer, secretary and treasurer; P. S. Graver, vice-president in charge of sales; W. F. Graver, vice-president; H. S. Graver, vice-president. Other plants of the Phoenix Company are located at Catasauqua, Pa.; Montreal, Canada, and Joliet, Ill.

Union Electric Bought by Cutler-Hammer Co.

Announcement has been made of the purchase of the Union Electric Manufacturing Company by Cutler-Hammer, Inc. This will add to the Cutler-Hammer products a line of drum type control apparatus.

The present factory of Union will be operated as a manufacturing division of Cutler-Hammer, and the branch sales offices and warehouse stocks will be consolidated with those of the purchasing company. Mr. E. F. LeNoir, president of Union, will become a member of the headquarters sales staff of Cutler-Hammer.

Paradon Moves Albany Office

The Paradon Manufacturing Company of Arlington, N. J., announces the removal of their Albany office from 467 Broadway to new and improved quarters at 1 Columbia Place. Announcement states that Mr. Paul M. Nickerson will continue in charge of this office and will handle the sales and service of Paradon chlorinators in Northern New York and Massachusetts.

Singer Kennedy Corporation announces the removal of their offices from 39 West Adams St. to Suite 904, 203 South Dearborn St., Chicago. This company specializes in the building of radial, common, and face brick chimneys; fire brick furnaces and high temperature fire brick work.

H. F. Kneen Promoted

Announcement has recently been made of the advancement of Mr. Harold F. Kneen to plant superintendent of the Lincoln Electric Company of Cleveland, O., manufacturers of "Linc-Weld" motors and "Stable-Arc" welders.

Mr. Kneen is a graduate of Cornell University, where he completed the course in Industrial Engineering and took the degree of Mechanical Engineer. While in college he took varsity letters in football and track for three consecutive years, and was chosen on several all-American teams. He took work in the Cornell graduate school, during which time he coached freshman football. He is a member of Tau Beta Pi, honorary engineering society, and of Chi Psi fraternity.

Previous to Mr. Kneen's connection with the Lincoln Electric Company he held positions in the Indiana Flooring Company, and was heat transfer engineer for the Ingersoll-Rand Company. He joined the Lincoln company just a year ago as assistant plant superintendent. With the announcement of his appointment as superintendent, comes word of the appointment of Mr. C. J. Bowers as production manager of the company's Cleveland plant.

Budd Wheel Company of Philadelphia and Detroit, according to announcement made by their secretary H. A. Coward, state net earnings, after all charges and reserves, to be $413,613.86 for the first quarter 1930. This is equal, after preferred dividend, to 40c per share on the common stock outstanding and compares with 55c a share earned on the common during the corresponding quarter last year, figures on the same number of shares.

The Brown Instrument Company, Philadelphia, Pa., announces the consolidation of its Chicago sales office and midwestern factory branch in new quarters located at 155 East Superior St., Chicago. The new arrangement will practically double their former space, and a large stock of replacement material will be carried on hand ready for prompt shipment.

Lincoln Electric Company of Cleveland announces the removal of their Baltimore, Md., distributor's office from 432 North Calvert St. to 600 North Calvert St. The change is to provide additional space for a complete stock of arc welding supplies for the Baltimore trade. Mr. T. A. Canty is in charge of the territory. Mr. R. Rude has been made office manager and Mr. C. N. Hilbinger, sales engineer and service manager.

Hooker Electrochemical Company announces the removal of its executive and sales office from 25 Pine St. to the Lincoln Building, 60 East 42nd St., New York City.

Two Ways to Speed Up the Job

"Get a move on, Tony"

"Specify TRIMO *on that order"*

IT'S often a far cry from the man who does the purchasing of tools to the man who uses them. But the purchaser can speed up work just as surely as the foreman on the job by specifying TRIMO where tongs or pipe wrenches are concerned.

In the oil fields where speed and safety mean a big return in dollars and cents, TRIMO is the leading wrench by a wide margin. The same holds true in water works and sewerage jobs. On any pipe wrench job, you will note a big difference with this strongest and safest of pipe wrenches — All Steel TRIMO.

TRIMO
Pipe Wrench

All Steel
Handle Drop Forged
--Not Cast

Made by **Trimont Mfg. Co., Inc., Roxbury (Boston), Mass.**

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Manufacturer's representative now handling centrifugal pumps would like to secure other lines in water works field. Covers eastern Pennsylvania, south Jersey and Delaware.

Bacteriologist would like to make connection with manufacturer for such work, or as assistant chemist.

Water Works equipment distributor, covering northeastern Indiana, would like to secure represenation of a line of chlorinators.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

A Michigan distributor, with many year's experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing incrased facilities in this region.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Manufacturer's representative with 25 years sales experience, conversant with all types of pumps and their field, desires agency for either New York or export territory, or both.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Representatives Wanted

Manufacturer of special valve and hydrant lubricant wishes to establish distributing points throughout the country.

Manufacturer of centrifugal pumps for water works, sewage plants, sand and dredging plants, process industry, contractors, etc., desires to secure additional representation. Attractive territory available.

Manufacturer of plows, grade-rippers and scrapers desires representation in Minnesota, Nebraska, North Dakota and Utah.

Manufacturer of street and traffic signs has attractive territory and proposition to offer distributors.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

Manufacturer of air compressors and contractors' tools has number of desirable territories open. Full co-operation will be extended to distributors.

Manufacturer of contractors and builders levels and transits is seeking district sales manager. Exclusive contract given. Excellent territory still available. Backed by national advertising.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of hoisting machinery and air compressors has open territory in New York and New England states for aggressive distributor.

Manufacturer of mechanical spreaders for cover material desires representation by organizations covering entire states. Several desirable states are still open. Number of inquiries now on hand for spreaders require immediate follow up.

Manufacturer of complete line or construction equipment, mixers, saw rigs, plaster and mortar mixers and pumps has an open territory in the state of Maine and is looking for an aggressive distributor to represent him there.

Long established and well-known manufacturer of industrial locomotives wishes to make contacts with qualified distributors. Locomotive line includes steam, gasoline, gas-electric and oil-electric. Supported by national trade journal advertising.

Manufacturer of cut to length, easily erected standardized steel highway bridges, for spans up to and including 40 feet, which are sold to highway commissioners and superintendents, has attractive territory open in states south and west of Chicago.

Manufacturer of Transverse Testing Machines desires to build up distribution organization in this country and abroad.

Manufacturer of plows, grade-rippers and scrapers desires representation in Arizona, New Mexico, Arkansas, Kansas and Louisiana.

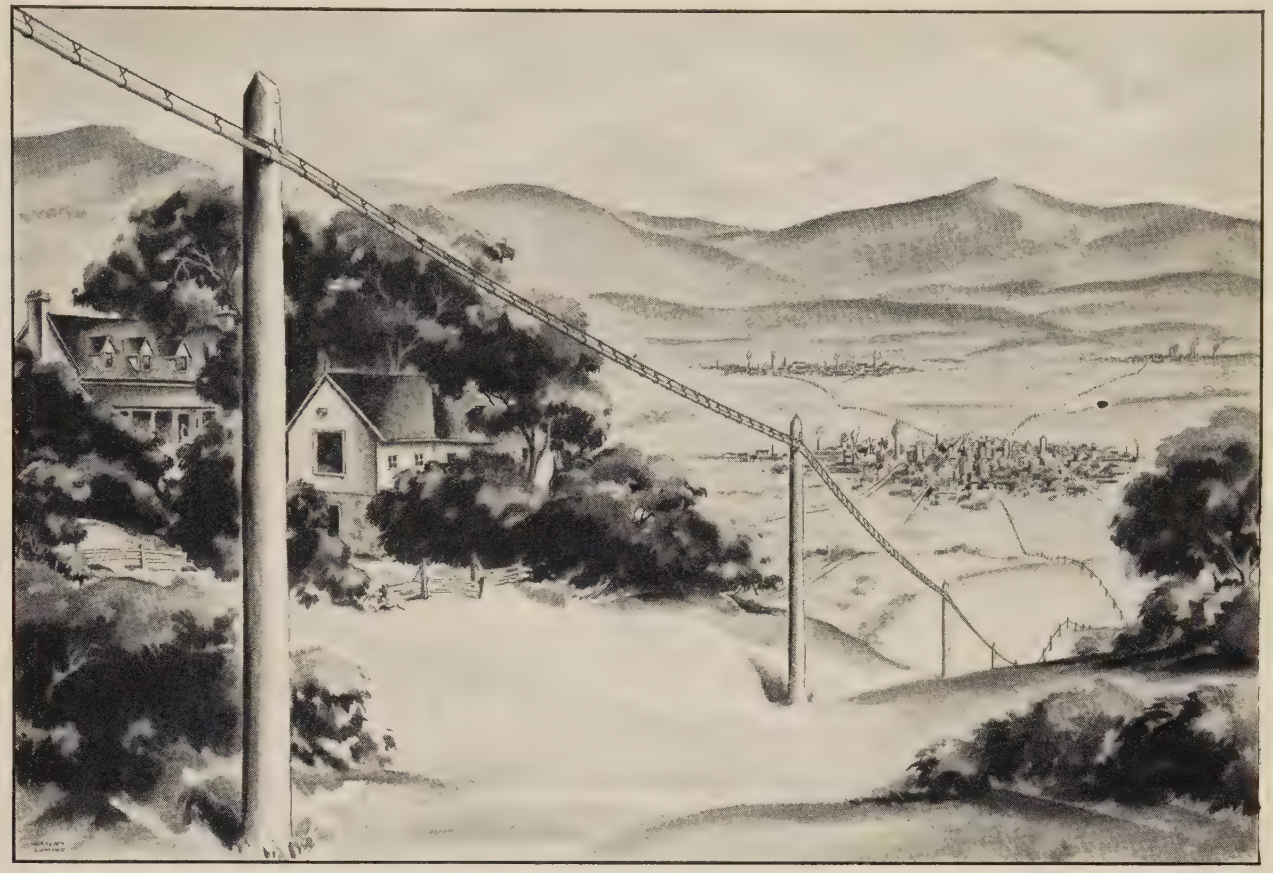
One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

Attractive territory available for experienced men to handle contractors' labor-saving equipment by old established company. Equipment backed by national advertising.

A manufacturer of paving expansion joints is looking for distributors for northern California territory.

Manufacturer of metal lath, corner beads, channels and reinforcing mesh desires to secure distributors for products in the southwest and middlewest.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.



AN INTER-CITY CABLE, PART OF THE BELL SYSTEM NETWORK THAT UNIFIES THE NATION

Vast, to serve the nation . . . personal, to serve you

An Advertisement of the American Telephone and Telegraph Company

So THAT YOU may telephone from house to house in a Southern village, from farm to farm in the Middle West, or from the Pacific to the Atlantic Coast—the Bell Telephone System *must* be large. Its work is to give adequate telephone service to one of the world's busiest and most widespread nations. There is 4000 million dollars' worth of telephone plant and equipment in the Bell System, any part of which is subject to your call day or night.

Every resource of this system is directed to the end that you may have quick, clear and convenient telephone service.

In order to meet the telephone needs of the country most effectively, the operation of the Bell System is carried on by 24 Associated Companies, each attuned to the area it serves. Working with these companies is the staff of the American Telephone and Telegraph Company, giving them the benefit of its development of better methods.

The Bell Laboratories and the Western Electric Company utilize the talents of thousands of scientists for constant research and improvement in the material means of telephony. Western Electric, with its great plants and warehouses in every part of the country, contributes its specialized ability for the precise and economical manufacture of equipment of the highest quality for the entire system.

The Bell System is vigorously carrying forward its work of improving the telephone service of the country. It is building for today and tomorrow—for the benefit of every one who lives and works in America.

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Michigan Valve & Foundry Buys Columbus Valve

The latest step to be announced in the expansion program of the Michigan Valve & Foundry Co. is the acquisition of the business, plant and assets of the Columbus Valve & Manufacturing Co., of Columbus, O., makers of plug type valves.

The Michigan Valve & Foundry Co. are licensees under the Meehanite metal patents, and the desirable physical qualities of Meehanite, will be utilized to extend the working range of both plug valves and gate valves.

The Columbus plant will continue to be used exclusively for plug valve production, while the gate valves, sluice gates and other Michigan products will be handled by the Detroit plant, it is said. The operations of both plants will be directed by Mr. R. J. Goldie, the company's general manager. Executive offices remain in Detroit.

F. D. West Made Sales Manager for Paradon

Announcement has been made of the appointment of Mr. Francis D. West as manager of sales for Paradon chlorinators, with headquarters at Arlington, N. J.

Mr. Francis D. West

Mr. West, for a number of years, was chemist in charge of the Torresdale Filter Plant, Water Department, Philadelphia, which city was among the first to use chlorination on a large scale.

For the past ten years Mr. West has been manager of sales for the Permutit Company in the territories of northern and western New York State.

Another item of interest concerning this company is the opening of an office at Pittsburgh, Pa. Mr. Ray S. Palmer is to be the representative in charge. By the new arrangement the Paradon Company will have increased facilities available for the sale and service of their products in Western Pennsylvania, Ohio and West Virginia territories.

Mr. Ray S. Palmer, to Head Pittsburgh Office of Paradon Mfg. Company

Roessler & Hasslacher Hold Sales Meeting at Niagara

Executives from the manufacturing plants and offices, together with sales force and service men, met recently at Niagara Falls to discuss the manufacture, service and sales of Roessler & Hasslacher products. Dr. H. R. Carveth, president of the company, was chairman of the convention meetings. Mr. J. E. Hatt, general manager of the duPont Cellophone Co., was the speaker at the annual banquet, which was held at the General Brock Hotel, Niagara Falls, Ontario.

Representatives from the various branches of the company in the United States, Canada and Mexico were in attendance.

American Steel & Wire Goes "Talkie"

One of the first successful "Talkie" industrial motion pictures has been produced by the American Steel & Wire Company, a subsidiary of the United States Steel Corporation.

Featuring a trip through the mills in which Wire Rope is made, the entire process becomes not only visible on the silver screen, but the illusion of actually being present is increased by the introduction of sound.

As each stage of manufacture is viewed, it is orally explained in a detailed and impressive manner. In this way many important points of interest, impossible to cover in the usual screen captions, are conveyed to the listener.

An added and novel feature is the use of lively music at certain spots where the action does not require conversation. This combining of entertainment with educational factors has proved unusually effective in maintaining interest to the highest possible pitch.

Although the adaptation of sound to industrial films is new, the remarkable success of this venture foreshadows a widespread use.

Simplex Valve Appoints Goldsborough & Vansant

The Simplex Valve & Meter Co. announces the appointment of Goldsborough & Vansant, Inc., Farmers Bank Building, Pittsburgh, as district representative for the Pittsburgh territory.

Mr. C. C. Behney, who formerly represented the Simplex Valve & Meter Co. in this territory, has been assigned to special work.

Announcement

The Board of Directors of Jenkins Brothers announces the election of Mr. James R. White as vice-president of the corporation and also his appointment as director of sales. This company, which is located at 80 White St., New York, is a well-known manufacturer of valves.

The Chicago Pump Co., of Chicago, announces the addition to their list of representatives of Mr. R. J. Welsh, 503 Healy, Atlanta, Ga.

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Strike Up the Band

The Manistee Iron Works believes that a band is not only good to produce harmony of sound but is likewise good for effecting harmony of effort and understanding. For this reason, when the band was organized about a year and a half ago, the officers of the company gave to the enterprise wholehearted moral and financial support. The company now boasts of a band in which each department of the plant and office is represented.

The band lists on its membership roll executives of the company, clerks, draftsmen, foremen and mechanics. The handsome uniforms resemble those of the Marine Corps, and because this is one of the largest industrial bands in the state of Michigan, and is the only one in the section of the country near Manistee, it is in great demand in its own town and in neighboring cities.

Although this musical organization is still quite young it has given a number of concerts, and, it is said, that the programs are selected with great care in order to meet the tastes of the listeners, and standard music with a wide variety of appeal is presented. Most of the band members own their own instruments, which are all of standard makes.

The Manistee Company takes a very just pride in this organization activity, and in referring to its formation, Mr. J. R. Ray, the president of the Manistee Iron Works Company, said: "We were fortunate in having quite a number of musicians in our employ, but as we thought a fairly large band was wanted, it was necessary to take in some who had no musical knowledge or experience. The different musicians of the band, however, volunteered their services and taught these beginners, and by dint of much intensive study and practice they have accomplished truly remarkable results."

Mr. Ray states that the company is favorably disposed towards activities of this nature because they do much to promote a healthy shop spirit and a better understanding between the different departments which can be accomplished in no other way. In addition to the band, the company boasts of baseball and basket-ball teams, both of which have records of successful seasons to their credit.

Editor's Note: Why wouldn't the attendance of some of the good industrial bands of the country at a few of the annual conventions do much to increase the attendance at conferences and program meetings?

ROSTER OF MANISTEE IRON WORKS COMPANY BAND, MANISTEE, MICH.

Band Officers: President, H. R. Ray; Vice-President, R. S. Topping; Secretary, J. D. Mish; Treasurer, Felix Johnson; Librarian, A. A. Mish. Personnel: Director, C. W. O'Donnell; Cornets, Stanley O'Donnell, David Kliber, Walter Gehrke, Harvey Ray, Frank Baker; Trombones, John Mish, Al Mish, Ray Ahlgren, Jack Leet, Louis Johnson, George Rydback, Lewis Daniels; Altos, Felix Johnson, Golden Eckholm, Norman Dewar, Gordon Radtke, Leslie Hummell, Ernest Jaekel, Richard Kylberg, Oscar Anderson; Drums, Elmer Ness, John O'Donnell, Gerald Mann; Clarinets, E. Gunderson, Chas. Hansen, Tony Raskey, Norman Chambers, Clarence Carlson, Casmir Pacholski, Al Anderson, Gerald Nott, I. Abrahamson, M. Jankowski, A. Mausolf, Rex Mix, Leo Pacholski, Ed Nowak, Austin Pehrson, Arthur Mason; Piccolo, Pat Thompson; Baritones, Robert Topping, Harlem Ray; Tenor, George Galvas; Basses, Carl Hedstrom, Clarence Kieft, Edward Hanson; Drum Major, Robert Bremer.

Peerless Pump Company Anticipates Big Year

Mr. E. M. Smith, chairman of the board of the Peerless Pump Company, states that their sales for this year already show a substantial increase over the corresponding period for last year, and he believes 1930 will prove a banner year for his company.

An expansion program has been inaugurated by Peerless to care for the increasing demand for their products, which includes the opening of a branch factory, and the appointment of several new representatives in various parts of the world. It is reported that the South American business of this company during the past eighteen months has exceeded $300,000.

The latest addition to the Peerless line is the completely protected Moturbo type pump head, sales of which, according to report, have greatly exceeded the estimates made for it.

Brown Instrument Company to Increase Plant

Owing to the continued growth of the demand for the products of the Brown Instrument Company of Philadelphia, contract has been let to Robert E. Lamb Company for 40,000 sq. ft. of additional floor space. Mechanical and electrical equipment will be installed under separate contracts with local concerns, according to recent report. This is the third successive year in which the company has been obliged to expand to meet their business requirements.

The new plans call for two additional floors on the new two-story concrete sections of the plant. Working plans are said to have been prepared by the Ballinger Company of Philadelphia, under the supervision of W. E. Camp, industrial engineer of the Brown Company. The company expects to occupy the new space in the early fall.

Indicating, recording and controlling instruments for industrial purposes, including pyrometers, flow meters and thermometers are included in the products of the Brown Company.

A Correction

An error occurred in the Who's Who Picture Gallery presented in the June issue of *Water Works & Sewerage* which we very much regret. The titles appearing under the names of Mr. Walter J. O'Day and Mr. Frank J. Egan, both identified with the cast iron pipe and foundry department of

WALTER J. O'DAY
Manager, Chicago
Cast Iron Pipe & Fdry. Dept.
James B. Clow & Sons

James B. Clow & Sons were transposed, the title belonging to Mr. O'Day appearing under Mr. Egan's name and vice-versa. The error occurred after proofs were read in shifting the various cuts in order to group together the representatives of the Clow company and those of the National Cast Iron Pipe Company.

FRANK J. EGAN
Assistant Manager, Chicago
Cast Iron Pipe & Fdry. Dept.
James B. Clow & Sons

Mr. Walter J. O'Day is manager and Mr. F. J. Egan assistant manager of the cast iron and foundry department of the Clow organization.

No Grief Here!

A report of 271 per cent increase in sales for the first five months of the present year over the same period for last year is the good news just received concerning the business of Tube-Turns, Incorporated, of Louisville, Ky., as announced by Mr. Walter H. Girdler, president of the Girdler Corporation, which operates the former company.

Tube-Turns are seamless forged, short-radius, uniform wall fittings for pipe welding, and Mr. Girdler states that for some time the plant has been operating twenty-four hours a day, six days a week, and due to the greatly increased business an expansion of facilities has been made necessary. Expansion now under way will allow for an additional production of 60 per cent, according to report of the president. Addition to the plant will be ready for use July 1, and the new equipment will be in operation Aug. 1.

This company maintains a chain of forty-four distributors and branches in this and other countries, and Mr. E. H. Courtenay, vice-president and director of sales, reports markets for their product in Hawaii, Canada, Central and South America.

Lukens Steel Company Forms Subsidiary

Announcement is made by Robert W. Wolcott, president of the Lukens Steel Co., of Coatesville, Pa., of the entry of this company into the field of supplying welded construction to the manufacturers of machinery and equipment. Research and development work in this connection has been going forward for several months and approximately 50,000 sq. ft. of manufacturing space has been provided at the Coatesville plant for this activity.

Operations in this field will be carried on through a subsidiary company known as Lukenweld, Incorporated, which for the present will utilize some of the manufacturing facilities of the parent company.

Mr. Wolcott states that rapidly increasing demand on the part of machinery and equipment buyers for welded steel construction is responsible for the new development. An extensive program of development and research work has been laid out to assure the safety and economy of welded steel design. They are prepared to furnish engineering assistance to users of this class of construction through a development and research division.

The new company has twenty-four operators working at the present time and expects to have fifty in production within the next sixty days.

Mr. G. D. Spackman is president of Lukenweld, Incorported.

New Distributor for Hercules Engines

The Hercules Motors Corporation of Canton, Ohio, announces the appointment of new distributors in various sections of the United States who will handle Hercules engines, power units and parts.

The new distributors are the F. C. Richmond Company, Salt Lake City, Utah, as exclusive distributor for the Mountain States; Worthington Machinery Corporation of Oklahoma, Tulsa, Okla., exclusive distributor for Oklahoma and adjacent territory; and Alamo Iron Works of San Antonio, Texas, who will sell Hercules engines and parts in the Winter Garden section of Texas. Each of these firms will carry a representative stock of engines and power units, together with a complete supply of parts for engines in service.

With the Smith-Booth-Usher Company of Los Angeles, Calif.; Edward R. Bacon of San Francisco, Calif.; the Norvell-Wilder Hardware Company of Houston, Texas, and Boviard & Company of Bradford, Penna., distributors for their respective territories, Hercules customers are now assured prompt and efficient sales and parts service in the far West, in the Mid-Continent and in the Pennsylvania oil fields.

In addition to the new representatives of Hercules in this country the manufacturer is extending the distribution of products in Europe. Announcement is made of the appointment of the Automotive Products Company, 3 Berners Street, London, W. 1., as sales distributors for Great Britain and the Continent. This distributing company maintains branch offices at Berlin (Zollernhof, 56 Unter den Linden), and at Vienna (1—Lobkowitzplatz).

It is stated by the manufacturers that the sale of Hercules will be pushed in the European market not only for commercial vehicles, but for use on general industrial equipment, agricultural and oil producing machinery of European make.

Paradon Manufacturing Company, Arlington, N. J., announces that Mr. M. B. Urquhart, 509 17th St., Denver, who is in charge of sales and service of chlorinators in the state of Colorado, has had his territory expanded to include Utah, Wyoming and New Mexico. Mr. Urquhart has just completed a month's visit to the factory at Arlington.

The Filtration Equipment Corporation announces the opening of its general offices in the Borden Building, 350 Madison Avenue, New York. Mr. W. C. Laughlin is president of this organization, which will serve the field of industrial and municipal sanitary engineering, specializing in processes and equipment for the economical removal of solids from liquids.

Aeroil Burner Company, Inc., whose headquarters are located in West New York, N. J., announces the opening of a Pacific Coast office and warehouse at 469 Bryant St., San Francisco, Calif., in charge of Mr. R. M. Starner.

Paradon Manufacturing Company announces the appointment of Mr. George Bird as assistant manager of sales, with headquarters at Arlington, N. J. Mr. Bird was formerly engaged in field sales and service work for this company.

THE MOST IMPORTANT INGREDIENT IN YOUR PIPE COATING IS

EXPERIENCE

The best solution to any of the problems that come up in the business of coating pipes is knowledge. Robertson has the knowledge. The H. H. Robertson Co. is the world's largest producer of special asphalts. It has made investigations in the action of soils on coating materials. It can determine the exact combination of asphaltic bases that are best calculated to protect your pipe under any given set of conditions . . . and it can produce exactly that combination.

Specify Robertson coatings on your pipes.

H. H. ROBERTSON CO.,
PITTSBURGH, PA.

ROBERTSON HAS THE EXPERIENCE

WATER CONTROL . . .

Without Floats or Fixtures

A constant level can be automatically maintained in reservoirs, tanks and standpipes by the use of

GOLDEN-ANDERSON Automatic "Cushioned" Controlling Altitude Valves

These valves are always cushioned in closing and opening. They are extensively used for automatically maintaining a uniform stage of water in reservoirs, tanks and standpipes. No valves inside. No floats or fixtures, inside or outside of tanks. No freezing troubles. Three ways of closing these valves:

1st—Automatically, by water.
2nd—By electricity, if desired.
3rd—By hand.

Remember: **Valves cushioned at all times by air and water. No water hammer or bursting mains.**

"Made with stop starter attachment for centrifugal pumps."

GOLDEN-ANDERSON VALVE SPECIALTY CO.
1386 Fulton Bldg., PITTSBURGH, PA.

GOLDEN-ANDERSON

Pat. Cushioned Water Relief Valves

1. Automatically relieve excess pressure.
2. Prevent stress, strain and busting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and globe pattern. Sizes 3 to 24-in.

GOLDEN-ANDERSON Patent Automatic Cushioned Controlling Float Valves

They carry a constant water level in feed water heaters by perfectly controlling the flow of makeup water.
Operated by protected enclosed copper float.
Cushioned by both air and water.
Operate without hammering, sticking or chattering. No metal-to-metal seats. Made angle or straightway.

Sizes ½ in. to 24 in.

Sizes ½ in. to 24 in.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Float Valves

1. Automatically maintain uniform water levels in tanks, standpipes, etc.
2. Instantly adjusted to operate quickly or slowly.
3. Floats swivel to any angle—Most satisfactory float valve known.
4. No metal-to-metal seats—No water hammer or shock.
5. Cushioned by water and air.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operate quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

Repauno Plant of duPont de Nemours Celebrates 50th Anniversary

A number of manufacturers in the American manufacturing of dynamite were present at the celebration of the 50th anniversary of the Repauno plant of E. I. duPont de Nemours & Company, held recently at Gibbstown, N. J. The celebration took the form of a company picnic attended by several hundred employees, and addresses were made by Lammot duPont, president of the duPont company; J. W. McCoy, general manager of the high explosives department, and others. P. C. Kaiser, plant manager was master of ceremonies, assisted by H. K. Babbitt, director of the high explosives manufacturing department.

Among those present was Herbert G. Chase, who occupied an executive position at the plant for forty-one years, and who retired nine years ago. Another veteran was H. Frank Young, still in active service after having completed a half century at the Repauno plant.

This plant was originally known as the Repauno Chemical Company, the first president being Lammot duPont, whose son is now president of the duPont Company. Mr. duPont predicted that this plant would become the largest dynamite plant in the United States, a prophecy which has been more than fulfilled, for it is now said to be the largest in the world.

Robert Bosch Truck Carried Renault Racing Car to S.A.E. Meeting

The Robert Bosch Magneto Co., Inc., exhibited and demonstrated its heavy oil engined truck at the summer meeting of the Society of Automotive Engineers, at French Lick, Ind., May 25 to 29. After this meeting this truck was driven to State College, Pennsylvania, for exhibition at the National Oil and Petroleum exhibition, held there June 12 to 14.

Previous to the S.A.E. summer meeting this truck was driven overland to French Lick from New York with a load consisting of the Renault racing car in which Marcel Renault won the Paris-Bordeaux race in 1921.

In addition one of the latest type Maybach-Diesel engines was carried. This was also on exhibition during the meeting.

Standard Road Equipment Announces Changes

At a recent meeting of the board of directors of the Standard Road Equipment Co., Inc., Mr. C. C. Fuller was elected to the office of president to succeed Mr. A. H. Puffer, resigned. It is stated that Mr. Puffer will continue as an active member of the company. Mr. Fuller formerly was connected with W. B. Louer Co. of Chicago.

Sales and service of the Allis-Chalmers Monarch Tractors and the Allis-Chalmers United Industrial Tractors for the northern Illinois counties are now handled by Standard Road Equipment Co. The company announces that a complete stock of repairs and replacement parts is kept in both Chicago and Rockford, and a force of mechanics is available from either point.

Mr. H. B. Faith is another former W. B. Louer Co. representative to join the sales organization of Standard. General offices and warehouse of this company are located at 2724 Auburn St., Rockford, Ill.

A MEETING OF THE CLANS

Maybe "Koehrings" aren't Scotch and this heading should read "A Meeting of the Gangs," but the point is they did meet. Two Milwaukee contractors, with two separate sewer jobs, happened to converge with the result that two pull shovels and five cranes all of the same family origin exchange friendly greetings and view the work of the paver being used for pouring concrete for the sewer forms.

Additional Western Offices for Hercules Motors

Announcement has been made of the appointment of Mr. Walter F. Radtke as Pacific Coast sales representative. Mr. Radtke, who formerly represented Hercules in the mid-continent states, took over his new duties on June 1st. Headquarters have been opened in the Russ Building, San Francisco, Calif.

Another office to be opened by this manufacturer is one at Tulsa, Okla., under the direction of Mr. R. J. Scott. This office will serve the Hercules customers in the mid-continent oil fields. Mr. Scott is located in the Mayo Building.

Announcement

Blaw-Knox International Corporation is the new name for the Export Organization of the Blaw-Knox Company, which was formerly known as Milliken Brothers-Blaw-Knox Corporation, which in turn succeeded the original Milliken Brothers Manufacturing Company.

This change in name is due to the larger scope of the company's activities and thoroughly identifies the Export Company as such. The change of name embraces no change in personnel and the offices will remain as formerly, in the Canadian-Pacific Building, New York City.

Blaw-Knox International Corporation handles all the products of the Blaw-Knox Company including road building equipment, clamshell buckets, central mixing plants, steel bins, measuring batchers, truck turntables, dragline buckets, agitator truck bodies, steel buildings, etc., in South America, the West Indies and other parts of the world where the Blaw-Knox Company is not otherwise represented.

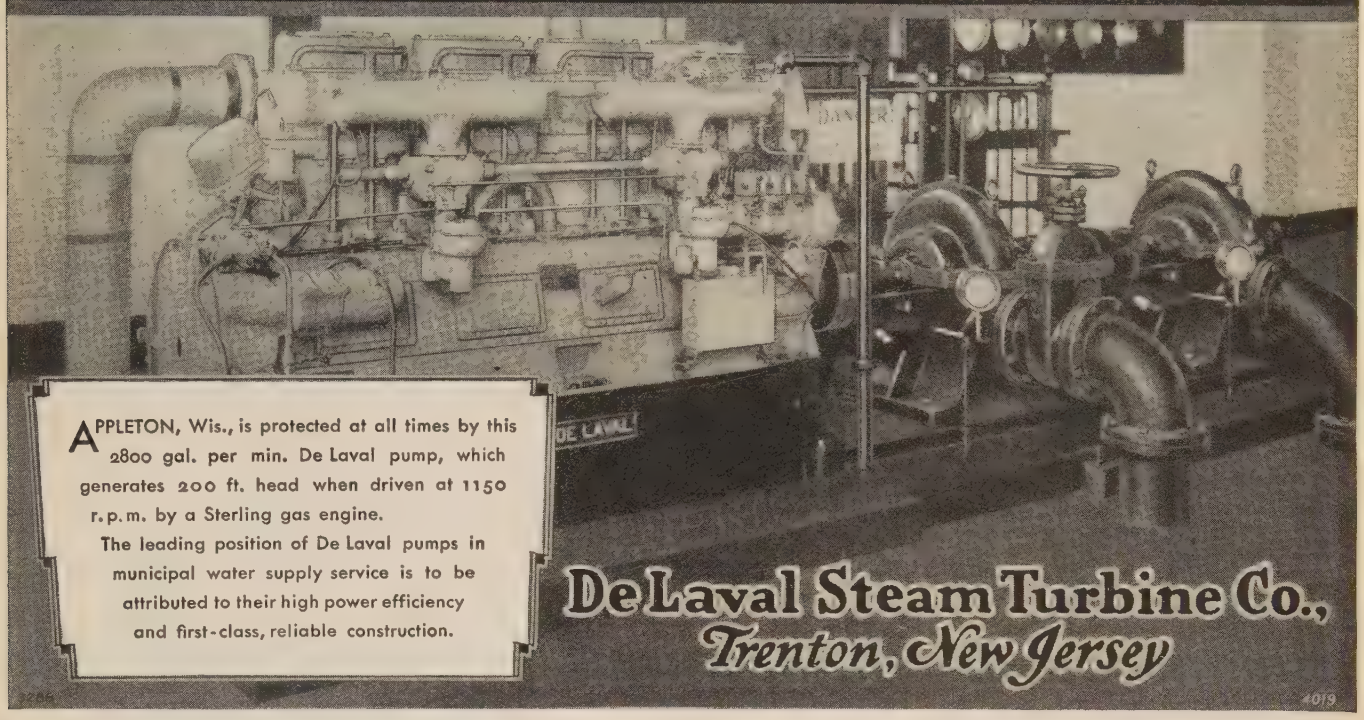
Ash Grove Lime & Cement Takes Larger Quarters

To better accommodate its many patrons, the Ash Grove Lime and Portland Cement Company announces the removal of its general offices. The entire eleventh floor of the Fairfax Building, located at 101 West 11th Street, Kansas City, Mo., has been taken over by this organization.

Official personnel of the Ash Grove Company, which was founded in 1882, includes: L. R. Sunderland, president; J. P. Pollock, vice-president; A. Lundteigen, vice-president; W. P. Sabin, vice-president and treasurer; A. B. Sunderland, secretary and asst. treasurer; W. R. Anderson, sales manager; J. L. Evans, asst. sales manager; G. N. Berry, asst. sales manager; W. S. Barton, traffic manager, and L. Kittle, general auditor.

Continental Motors Corporation announces that schedules have been arranged so that all employes will be given their annual vacations from June 29th to July 14th.

De Laval Pumps
make water supply certain



APPLETON, Wis., is protected at all times by this 2800 gal. per min. De Laval pump, which generates 200 ft. head when driven at 1150 r.p.m. by a Sterling gas engine.

The leading position of De Laval pumps in municipal water supply service is to be attributed to their high power efficiency and first-class, reliable construction.

De Laval Steam Turbine Co.,
Trenton, New Jersey

CUSHIONING CONCRETE HIGHWAYS against the heavy pounding of traffic . . . adding extra years of repair-free smoothness . . . that's the job of Carey Elastite Expansion Joint! Unaffected by extemes of heat or cold! Comes in flexible, preformed strips . . . easy to handle . . . inexpensive. Yes, quick deliveries!

Carey Elastite EXPANSION JOINT
TRADE MARK REGD. U.S. PAT. OFF.

THE PHILIP CAREY COMPANY
Lockland
Cincinnati, Ohio

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

West Coast distributor, specializing in materials for sewers and water works, is in a position to render splendid representation for territory covered.

Manufacturer's representative, with warehouse facilities available, would like to secure additional lines in water works and sewerage and general contracting fields. Covers Houston and San Antonio territory.

Water Works equipment distributor, covering northeastern Indiana, would like to secure represenation of a line of chlorinators.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Bacteriologist would like to make connection with manufacturer for such work, or as assistant chemist.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Manufacturer of centrifugal pumps for water works, sewage plants, sand and dredging plants, process industry, contractors, etc., desires to secure additional representation. Attractive territory available.

Manufacturer's representative now handling centrifugal pumps would like to secure other lines in water works field. Covers eastern Pennsylvania, south Jersey and Delaware.

Manufacturer's representative with 25 years sales experience, conversant with all types of pumps and their field, desires agency for either New York or export territory, or both.

Distributor covering New Jersey and New York territory would like to secure a line of street markers or other traffic equipment on exclusive basis.

Equipment distributor in Pacific Northwest desires line of road building equipment, structural building equipment, dump bodies and truck hoists.

Machinery distributor established in Porto Rico and Santo Domingo would be pleased to make arrangements to take on new lines in these territories.

Representatives Wanted

Manufacturer of special valve and hydrant lubricant wishes to establish distributing points throughout the country.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of air compressors and contractors' tools has number of desirable territories open. Full co-operation will be extended to distributors.

Manufacturer of contractors and builders levels and transits is seeking district sales manager. Exclusive contract given. Excellent territory still available. Backed by national advertising.

Distributors wanted to represent improved type of snow fence. Good territory in various parts of country.

Hunter Machinery to Represent Trackson Co.

The Trackson Co., Milwaukee, Wis., announces the appointment of the Hunter Machinery Co., 16th St. Viaduct, Milwaukee, Wis., as a new distributor of Trackson tractor equipment.

This company has branches located

Mr. M. R. Hunter

at 221 S. Waterman Ave., Detroit, Mich., and at 530 Monroe Ave., N. W., Grand Rapids, Mich. They will handle Trackson crawlers, shovels, cranes, hoists, etc., and will be able to give prompt service on all orders for machines as well as for repair and replacement parts.

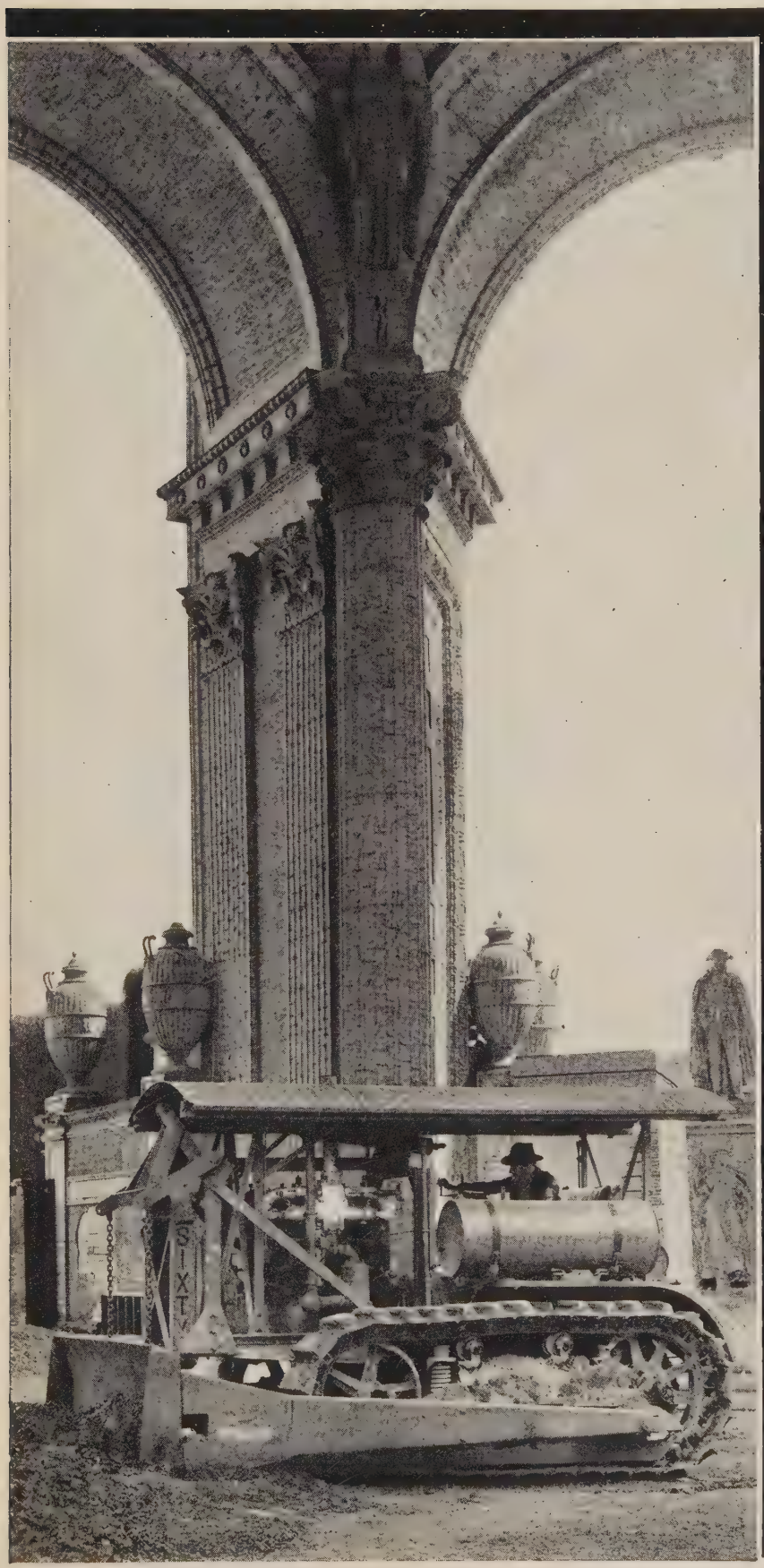
Mr. Morton R. Hunter is president of the company bearing his name.

Sullivan Machinery Company of Chicago, manufacturers of portable and stationary air compressors, rock drills, concrete breakers, portable hoists, drill sharpeners, etc., announce the appointment of the Carolina Contractors Equipment & Supply Company, 824 Lady St., Columbia, S. C., as distributors for their products.

Old Wheeling Firm Announces Merger

The Wheeling Mold Foundry Company, Duquesne Steel Foundry and Hubbard Steel Foundry will in future be operated as Continental Roll & Steel Foundry Company, according to recent information.

PARKS . PLAYGROUNDS,



or GOLF COURSES

A "CATERPILLAR" TRACTOR, once it's bought and put to work, lends willing power to scores of tasks. Many cities keep their "Caterpillars" busy the year 'round—snow plowing in winter, building roads, improving parks, leveling garbage dumps and doing jobs of all sorts. The picture shows a Sixty and bulldozer operated by San Francisco's park system.

Prices—f. o. b. Peoria, Illinois

TEN . .	$1100	TWENTY	$1900
FIFTEEN .	$1450	THIRTY .	$2375
SIXTY			$4175

Caterpillar Tractor Co.

PEORIA, ILL. *and* SAN LEANDRO, CAL., U. S. A.

Track-type Tractors Combines Road Machinery

(There's a "Caterpillar" Dealer Near You)

CATERPILLAR
REG. U. S. PAT. OFF.
TRACTOR

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Yeomans Brothers to Test Cooperative Plan

With a view to stabilizing employment, reducing operating costs, securing improvements in design and quality of products, and better operating conditions Yeomans Brothers Pump Company and representatives of the International Association of Machinists met in conference and adopted a systematic plan of cooperation which will enable the employees to share in the resulting gains.

The system agreed upon between the union and the management of the manufacturing organization is similar to the famous plan in operation for some years on the Baltimore and Ohio Railroad. Otto S. Beyer presented the proposals of the International union in the negotiations for a plan. Mr. Beyer was the consulting engineer who was active in developing the plans for the employees' participation in use in the Baltimore and Ohio and Canadian National Railways systems.

The formal acceptance of the plan is said to mark the first time such a scheme has ever been introduced in a factory of this size, although it has won renown on large-scale operations. The fact that Yeomans Brothers has operated on a union basis for more than twenty-five years is given as one of the factors making possible the successful adoption of the plan.

Yeomans Brothers Company, located in Chicago, are well-known manufacturers of sewage ejectors and pumping machinery.

Byers Closes Hand Puddle Mill

The Girard, Ohio, hand puddle mill, operated by the A. M. Byers Company, and said to be the largest single unit of hand puddle furnaces in the country, was recently closed. The discontinued Girard plant was built in 1908, and, in addition to 88 puddle furnaces and the plate mill, included a blast furnace which was dismantled in 1929.

In anticipation of the opening of the new mill which this company recently completed on the Ohio River just outside of Pittsburgh, plans have gradually been going forward for the consolidating of the manufacture of wrought iron in the Pittsburgh district. In comparison of the Girard's plant capacity of 5,000 tons a month, the new mill is expected to have a capacity of 45,000 tons a month.

It is stated that, according to United States Bureau of Standards, the wrought-iron produced by the Byers' new process has a highly refined base iron and uniform distribution of iron-silicate. With the new process now in operation Byers is enabled to manufacture wrought-iron on a scale which permits them to roll plate for pipe directly from the billet instead of piling and re-heating much bar. It is stated that pipe made from the new method will possess better bending and threading properties than those found in hand puddled products.

The new mill affords the manufacturer facilities for producing plate and iron bar, although it is thought that for some time to come wrought-iron pipe will be the finished product.

Three Time Winner of Safety Trophy

Mayor C. F. Snively and R. J. Fisher, president of the Advisory Public Safety committee, of Duluth, were the principal speakers at the recent field day celebration of the Duluth plant of the Universal Atlas Cement Company as winner for the third time of the no-accident safety trophy.

The trophy was presented by George A. Ricker, representing the Portland Cement Association, and was accepted for the Duluth plant by Fred Robinson, assistant superintendent.

A colorful feature of the celebration occurred when 955 gas-filled balloons were brought onto the field by 32 boy scouts, each scout representing one month of the mill's consecutive no-accident record, and after the boys had formed the letters "SAFETY" the balloons were simultaneously released.

Each of the balloons carried a tag bearing a safety message, a "Safety Crusader" badge of the National Safety Council, and a reproduction of a safety poster. Prizes were offered to the finders of the balloons traveling farthest from the Duluth plant. Each tag carried the name of an employe, and prizes were awarded to the employes whose balloons traveled farthest.

Following the ceremonies attendant upon the unveiling of the trophy, a picnic luncheon and athletic events completed the program.

Wallace & Tiernan Make Changes in Personnel

F. G. Merckel, for the past eight years manager of Wallace & Tiernan Company's Chicago office, has been appointed sales manager of Wallace & Tiernan Products, Inc., with headquarters at Belleville, New Jersey, according to recent announcement in regard to several personnel changes.

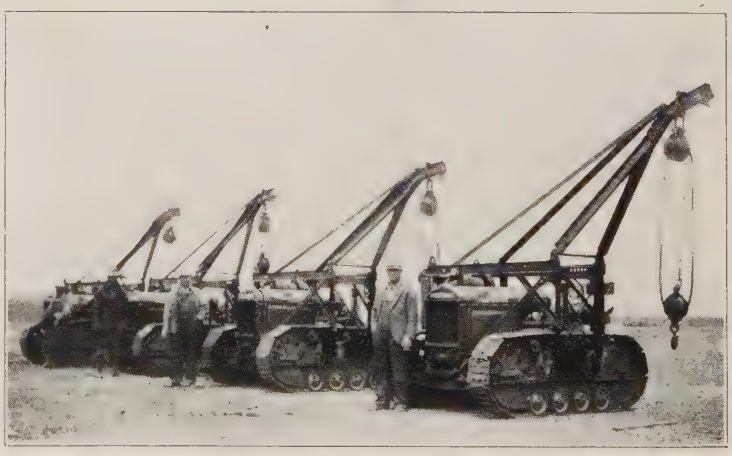
The position left vacant by Mr. Merckel will be filled by C. O. Bruden, formerly assistant manager.

In the Indianapolis district, W. A. Hockett has been transferred from the position of manager of the district office to the home office of the company at Newark, New Jersey, to take charge of the foreign activities. E. F. Kinney has been appointed district manager to succeed Mr. Hockett.

Charles H. Eastwood, who was formerly in charge of foreign sales, has been placed in charge of advertising and publicity for the Wallace & Tiernan Company and Wallace & Tiernan Products, Inc.

European Correspondent for Link-Belt Co.

William Piez, brother of Charles Piez, chairman of the Link-Belt Company, has been appointed European correspondent, according to recent announcement of Humphrey L. Kiely, head of the export division. His Paris address will be Hotel Lutetia, 43 Boulevard Raspail.



They Reach for a Pipe

Part of a fleet of Trackson-McCormick Deering crawler tractors with Seminole pipe handling booms which were recently purchased from the Industrial Machinery Company of Kansas City by Knupp & Fredell, Kansas pipe line contractors.

All-Steel glass sludge bed enclosures *for Dunkirk*

The new sludge bed plant of the City of Dunkirk, New York, is equipped with two American-Moninger glass sludge bed enclosures of all-steel construction. One enclosure is 75 feet wide by 125 feet long and the other is 74 feet wide by 250 feet long. The use of these glass sludge bed enclosures permits three or four times the number of dryings as compared with open sand beds.

American-Moninger has ample facilities to handle all types of sludge bed coverings. Preliminary plans and specifications furnished on request. Write for estimates.

Since 1869

American-Moninger Greenhouse Manufacturing Company

SOUTHWEST OFFICE
2611 North Dewey St.
Oklahoma City, Okla.

1365 Flushing Avenue
Brooklyn, New York

WESTERN OFFICE
1313 W. Randolph Street
Chicago, Ill.

THE MOST IMPORTANT INGREDIENT IN YOUR PIPE COATING IS

EXPERIENCE

The best solution to any of the problems that come up in the business of coating pipes is knowledge. Robertson has the knowledge. The H. H. Robertson Co. is the world's largest producer of special asphalts. It has made investigations in the action of soils on coating materials. It can determine the exact combination of asphaltic bases that are best calculated to protect your pipe under any given set of conditions . . . and it can produce exactly that combination.

Specify Robertson coatings on your pipes.

H. H. ROBERTSON CO.,
PITTSBURGH, PA.

ROBERTSON HAS THE EXPERIENCE

Retirement of Geo. W. W. Cornman Announced

Announcement has been made of the retirement of George W. W. Cornman, treasurer and manager of the Service Department of The Brown Instrument Company of Philadelphia.

Mr. Cornman, who was formerly secretary and treasurer of the Keystone Electrical Instrument Company, has been associated with the instrument business for 35 years. When the Brown Company absorbed Keystone, Mr. Cornman was made a director and treasurer, and under his guidance built up the service department, of which he was the head.

The service department is now in charge of R. C. Kennan, manager, and E. T. Nahill, field supervisor.

T. L. Lewis Joins Norvell-Wilder Supply Company

T. L. Lewis, who for the past 18 years has been associated with the A. M. Byers Company of Pittsburgh, has resigned to become associated with the Norvell-Wilder Supply Company of Beaumont, Texas, distributors of oil country goods. For the past 12 years Mr. Lewis has served the Byers company as general manager of sales.

Another change in the ranks of the Byers company has been caused through the resignation of George E. Clifford, Pittsburgh division manager, who has been made assistant sales manager of the pipe division of the Republic Steel Corporation.

Worthington Pump Reports Improved Financial Status

A recent report issued by the Worthington Pump and Machinery Corporation of Harrison, New Jersey, in addition to maintaining good earning power indicates an improved financial status during the first half of the year.

As of June 30, current assets were $17,525,690 against current liabilities of $1,225,722. Cash, call loans and government security holdings were reported as $6,920,560, 465% in excess of total liabilities. Inventories, as of the same date, totaled $5,662,733; reserves $1,674,920; and surplus $5,701,103.

Corresponding figures for the first six months of 1929 were: Current assets, $16,532,255; current liabilities, $813,707; cash, call loans and government securities, $5,645,932; inventories, $6,649,069; reserves, $1,896,622; and surplus, $5,028,025.

The net income of $1,052,732 for the first half of 1930, after deducting all charges, including taxes and depreciation, was reported as substantially larger than the total net for each of the full years 1922 to 1928, inclusive, and only $46,696 less than that reported for the corresponding period of 1929.

The first half net of this year was equal to $4.31 a share on the 126,921 shares of $100 par common stock outstanding, compared with $4.57 a share on 129,921 shares of common issued in the first half of 1929.

J. R. Dangler Made Secretary Cast Iron Pipe Research

Announcement has been made to the effect that the Standardization and Development Committee of the Cast Iron Pipe Research Association has secured the services of J. R. Dangler as secretary to handle the standardization and development work of the cast iron pipe industry.

Mr. Dangler's office will be located at 923 Union Trust Building, Cleveland, Ohio. Mr. Dangler has formerly held executive positions with the Massillon Iron and Steel Company and the Central Steel Company of Massillon.

New Representatives for Paradon Mfg. Co.

The Industrial Sales Company have recently taken on Mr. Miller, who will specialize in the service and sale of Paradon chlorinators in the Omaha territory. Nebraska and western Iowa are included in the territory to be covered.

Percy L. Luck will represent the Paradon Company in the states of Louisiana and Mississippi. Mr. Luck will have a complete stock of parts, as well as chlorinators, to aid him in the sales and service work for Paradon. This manufacturer was formerly represented in this territory by the firm of Buckmaster-Luck-Malochee, Inc.

New San Francisco Plant for Link-Belt Co.

A modern plant, employing the latest designs in tools, most up-to-date methods of production, and an engineering organization capable of applying labor-saving machinery for every industry, describes the new manufacturing plant and office of the Pacific Division of the Link-Belt Company. It is located at Paul Ave. near Bayshore Highway.

The office building is of Spanish design, two stories high; the warehouse 80x120 ft., is three stories high, and the manufacturing building, containing the machine shop, steel shop, plant office and their auxiliary departments completes the unit.

All kinds of elevating, conveying and power transmission machinery is manufactured within the plant, assuring quick and efficient service to the Link-Belt customers, and is one more well equipped unit in the Link-Belt's 16 plants and warehouses located throughout North America.

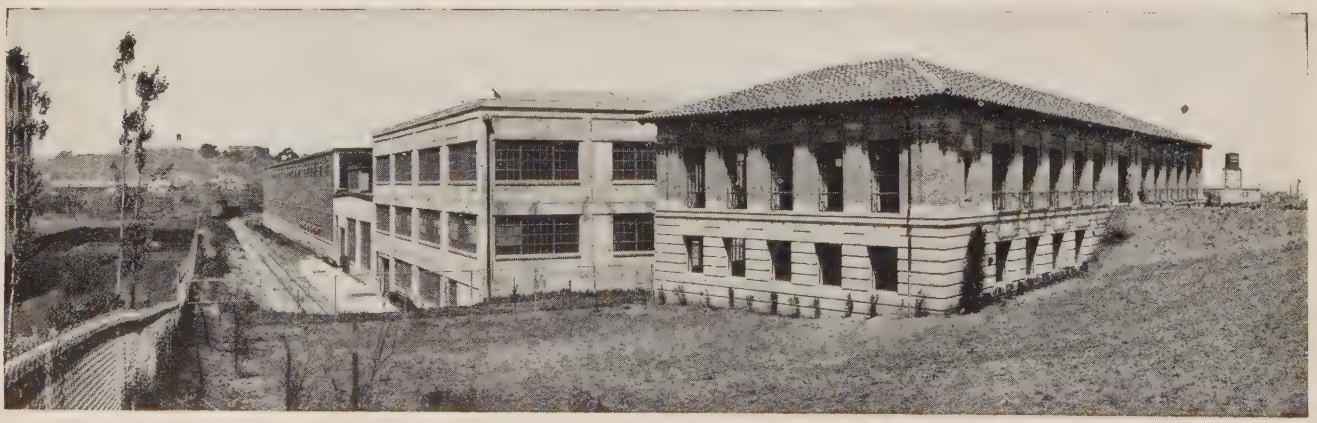
What's Your Guess?

A guessing contest on tensile strength of oxy-acetylene welded test coupons which will be pulled on the Oxweld Portable Tensile Testing Machine, will be a feature of the exhibit of the Union Carbide and Carbon Corporation at the National Metal Congress and Exposition where the subsidiaries of this corporation will occupy Booths 81 and 82 to display their products.

The exposition is to be held at the Stevens Hotel in Chicago from September 22 to 26, and will be the twelfth annual National Metal Congress. Among the units of the Union Carbide organization participating will be The Linde Air Products Company, The Prest-O-Lite Company, Inc., Oxweld Acetylene Company, Haynes Stellite Company, The Oxweld Railroad Service Company and Union Carbide Sales Company.

"Everything for Oxwelding and Cutting Everywhere" will be emphasized by displays of Linde oxygen, Prest-O-Lite acetylene and small tank apparatus; welding and cutting blowpipes; carbide in drums, flood lights and carbic and processed carbide.

The booths of the Union Carbide will be in charge of E. J. Hayden of the Chicago office and H. H. Griffith of the New York office. H. F. Bulkley and T. C. Fetherson of the New York office and several Chicago sales representatives will also be in attendance and the Oxweld Railroad Service men are looking forward to greeting some of their railroad friends who will be in Chicago at the same time attending the Railroad Master Blacksmiths' Association Convention.



San Francisco Plant of Link-Belt. Front to back, in order: Office Building, Warehouse, Shipping Room and Manufacturing Building

PITTSBURGH DES MOINES

300,000 gallon tank on a 100 foot tower at Grinnell, Ia. The tank is 36 feet in diameter, 28 feet 1¼ inches high with a riser 48 inches in diameter. Completed June, 1930.

Cut the Costs of Forced Pumping

Water pumps that labor 24 hours a day to keep mains full are no longer necessary. By filling an elevated tank during slack hours, the same pumps can create a cost-saving reserve supply of water in a PDM tank of proper capacity, that will service the entire city adequately during peak load hours.

A strong elevated gravity pressure will save the cost of torn-up streets to install larger water mains. Inadequate service often results from the *low pressure* available, and *not* from too small water mains.

Our 48 page Municipal Water Works Catalog tells how other cities have cut their water supply costs. Write for a copy.

Pittsburgh-Des Moines Steel Company

3404 Neville Island, Pittsburgh, Pa.
906 Tuttle St., Des Moines, Ia.

New York
Dallas
San Francisco

Chicago
Atlanta
Seattle

Sewage Disposal need not be *disagreeable!*

King Sludge Bed Enclosures Are Attractive in Appearance And Give Perfect Odor Control . . .

This scientific method of sludge drying effectively eliminates the big objection to sewage disposal plants, viz., the constant odor. With King Enclosures, this odor is controlled by a ventilating system which renders it negligible. A slight soapy smell, occasionally, is all that is ever detected.

There are other advantages. In consequence of the elimination of the disagreeable odor feature, it is now possible to locate the disposal plant nearer to the center of population. The economy of this is obvious. Sludge bed capacity is increased, too, with King Enclosures: It being possible to serve twice the population without enlarging the beds. Sludge drying proceeds efficiently the whole year, regardless of the weather. Sludge may be run to a greater depth and dried more quickly.

We should be pleased to send you full particulars. No obligation. Just mail us your letterhead.

Plant shown above: Two 48x97 ft. King Enclosures erected for Boroughs of Bergenfield & Dumont at Dumont, N. J. Engineer: Thomas F. Bowe.

KING CONSTRUCTION COMPANY

533 Wheatfield Street
North Tonawanda, N. Y.

NEW YORK CITY PHILADELPHIA, PA. BOSTON, MASS.
SCRANTON, PA. TOLEDO, OHIO SCHENECTADY, N. Y.
BRIDGEPORT, CONN.

OUR CATALOGUE IS FILED IN SWEET'S

Frank J. Oakes, Well Known Engineer, Dies

Apoplexy was the cause of the sudden death of Frank J. Oakes at his Indianapolis home on July 19th. Mr. Oakes was general superintendent of the Dodge Works of Link-Belt Company of Indianapolis. He was 54 years old, and well known in the mechanical engineering field.

Mr. Oakes was born in Decatur, Ill., in 1875, and entered the service of the Link-Belt Machinery Company of Chicago in 1894, as repairman and general machinist. In 1899 he obtained a year's

Frank J. Oakes

leave of absence to serve as repair man for the Mexican Central Railway in Chihuahua. Returning to the Link-Belt Company in Chicago he continued to serve as repairman and as assistant foreman in the sheet and structural iron department. In 1913 he was transferred to Philadelphia, and two years later went to Indianapolis to become general superintendent of the Dodge Works, which position he held until his death.

He was a recognized authority on mechanical engineering and during the World War was selected by the government as a designer and adviser on the manufacture of munitions. He was sent to Europe by the Link-Belt Company to investigate new mechanical inventions and to study chain manufacturing processes. He was a pioneer in developing processes for the heat treatment of steel and contributed valuable information to heat treaters as a result of his experiments. He also held patents on inventions in the chain industry and in other fields.

Mr. Oakes was active in local business and lodge circles. He was a member of the Society of Automotive Engineers, the American Society of Steel Treaters, the American Gear Manufacturers' Association and several other engineering societies. He was a past master of Evergreen Lodge, A. F. and A. M., a member of the Shrine, the Knights Templar and the Odd Fellows. He was also a member of the Avalon Country Club of Indianapolis. Engineering and industry has lost one of its leaders.

International Nutyp Successor to Oswego Tool Company

A complete change of management was announced with the sale of the Oswego Tool Company to the International Nutyp Tool Corporation of Oswego, New York.

H. W. Stone, formerly president of the U. S. Hoffman Machinery Corporation, has been made president and general manager of the new corporation. E. B. Russell, formerly head of the Security Finance Company and sales manager for Peerless Mills, Inc., will serve the new company as vice-president and treasurer, and E. W. Fulton, who for several years has been manager of the Oswego Tool Company, will become works manager and vice-president of the company.

It is stated that a new system of merchandising will be put in operation, and new tools will be added to the Oswego line. It is possible that some contemplated mergers of other companies with International may bring about a further expansion of this organization.

Chain Belt Announces New Distributors

The following distributing companies have recently been appointed to handle the complete line of Rex construction equipment manufactured by the Chain Belt Company of Milwaukee:

The Equipment Corporation of Arizona at Phoenix; F. C. Crane Company, Dallas, Texas; Joe C. Tucker, Morganfield, Ky.; Track-Type Tractor and Equipment Company, Amarillo, Texas, and Concrete Products Company of Oakland, Cal.

In addition to the new construction equipment distributors, the Chain Belt Company has appointed the E. C. Atkins and Co., Inc., Memphis, Tenn., as chain and power transmission representatives. The Atlanta office of the company has recently been moved to 407 Bona Allen Building.

Guiler to Represent Ateco in Pacific Northwest

Homer L. Guiler, for the past four years connected with Hofius-Ferris Equipment Company of Spokane, has been appointed district representative in the Northwest for the American Tractor Equipment Company, according to announcement of Edward R. Bacon, president of the firm, which manufactures Ateco earthmoving equipment.

Homer L. Guiler

Mr. Guiler, according to announcement, is thoroughly familiar with earthmoving, particularly in the Northwest, having been in the machinery business for 10 years, always as a salesman of tractors or graders. Prior to his connection with the Hofius-Ferris Company he was employed by the Connelly Machinery Company, "Caterpillar" dealer of Billings, Montana, and by the Northwest Equipment Company of Butte.

He has been assigned the entire Pacific Northwest for the American Tractor Co. and will cover Oregon, Washington, Idaho, Wyoming, Montana, Utah, North Dakota, South Dakota and Minnesota.

C. B. Spicer Retires

After 43 years of continuous service in the explosive business, Charles B. Spicer, resident manager of the St. Louis office of the Hercules Powder Company, has retired, according to recent announcement.

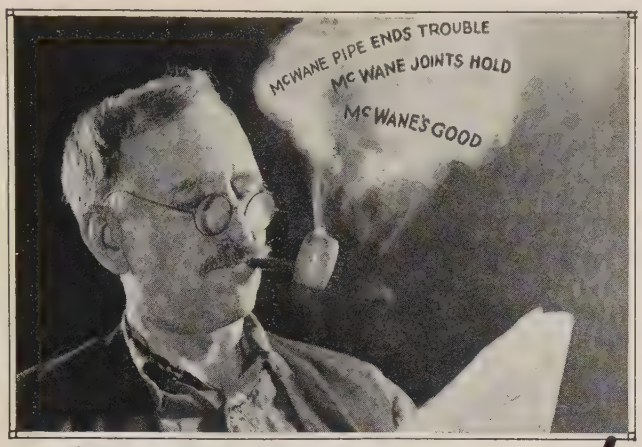
Born in St. Louis in 1869, where he received his education, Mr. Spicer entered the explosive business as an office boy for the Hazard Powder Company, subsequently becoming a salesman for them. He went to Pittsburg, Kansas, as an explosives sales agent, and in 1913 was made manager of the Pittsburg office for the Hercules Powder Company. In 1921 he was transferred to his home town as resident manager in charge of the Southwestern district.

Mr. Spicer, while in Pittsburg, Kansas, was active in civic affairs, serving as president of the Chamber of Commerce, and also was Exalted Ruler of Elks. He is now making his home at 742 Boland Drive, St. Louis.

The Independent Pneumatic Tool Company, Chicago, manufacturers of Thor Pneumatic and Electric Tools, have appointed Mr. C. T. Connelly manager of the Buffalo office. Mr. Connelly formerly worked in the Michigan territory out of the Detroit office.

Service Exchange has been helpful in securing desirable representation for the products of many manufacturers and in assisting distributors in building up their lines. Do not hesitate to make use of this service which the publishers present as a regular feature of this magazine. For information write, Editor, Distributor News.

Following the trend of the times, McWane Cast Iron Pipe Company, of Birmingham, Ala., tie up their pipe stories with events of the day and tell them in picture tabloids in their little paper called "Pipe Pointers."



Two Pipes of Peace!

To have peace in his mind, a water-works man's got to have cast iron pipe in his mains. *Then* the old cob pipe "hits on all six" when his day's work is done; he knows rust and rot cannot harm his distribution system this year, next year—or next century. Cast iron *lasts*.

And the wiser ones have extended a good idea downward too, into the 1¼ and 2 inch sizes—adopted McWANE cast iron pipe for the small outlying lines, for the newly-popular two-main systems in residential blocks, and for services everywhere.

Get New Booklets

Bring your pipe-facts up-to-date with the new McWane booklets. Learn of new advantages, new uses for cast iron pipe in your field. 2-inch pipe in 18-foot laying-lengths now. New sizes of Precalked Joint and open bell B. & S. McWane pipe—up to 12 inches. At least *find out* what McWane pipe can do for you.

WRITE FOR ILLUSTRATED LITERATURE

McWANE

CAST IRON PIPE

McWANE CAST IRON PIPE COMPANY *BIRMINGHAM, ALA.*

PACIFIC STATES CAST IRON PIPE COMPANY *PROVO, UTAH.*

SALES OFFICES, PRINCIPAL CITIES

Two 400 H.P. Pomona Turbine Pumps installed for the City of Augusta, Georgia.

Pumps that stay young

Pomona Turbine Pumps are designed and built to give many additional years of dependable service. Municipal Water engineers have found that these water-lubricated pumps assure an absolutely clean water supply. Pomona Pumps do not require frequent inspection, a factor which makes them unexcelled for automatic operation.

Factory representatives, sales and service offices in all principal cities. Name of nearest one and Bulletin on request.

Pomona Pump Co., Pomona, Calif.

POMONA

WATER LUBRICATED TURBINE TYPE

Oceans of Water

PUMPS

[Ask for Catalog]

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives of their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Water works equipment distributor, covering northeastern Indiana, would like to secure representation of a line of chlorinators.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

West Coast distributor, specializing in materials for sewers and water works, is in a position to render splendid representation for territory covered.

Manufacturer's representative, with warehouse facilities available, would like to secure additional lines in water works and sewerage and general contracting fields. Covers Houston and San Antonio territory.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Manufacturer's representative now handling centrifugal pumps would like to secure other lines in water works field. Covers eastern Pennsylvania, south Jersey and Delaware.

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A Michigan distributor, with many years' experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing increased facilities in this region.

Manufacturer's representative located in New York City, now handling pumping machinery, would like to take on two or three additional lines serving the same field as his present account.

Michigan distributor would like to add two or three good lines to serve territory in southwestern part of state.

Machinery distributor, established in Porto Rico and Santo Domingo, would be pleased to make arrangements to take on new lines in these territories.

Manufacturer's representative, covering Massachusetts, Rhode Island and southern New Hampshire, would like to secure line of speed reducers and gears.

Manufacturer's representative with 25 years sales experience, conversant with all types of pumps and their field, desires agency for either New York or export territory, or both.

▼

Representatives Wanted

Manufacturer of special valve and hydrant lubricant wishes to establish distributing points throughout the country.

Manufacturer of centrifugal pumps for water works, sewage plants, sand and dredging plants, process industry, contractors, etc., desires to secure additional representation. Attractive territory available.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of air compressors and contractors' tools has number of desirable territories open. Full co-operation will be extended to distributors.

Distributors wanted to represent improved type of snow fence. Good territory in various parts of country.

Manufacturer of contractors and builders levels and transits is seeking district sales manager. Exclusive contract given. Excellent territory still available. Backed by national advertising.

One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

•

Just Enough Heat

The Marsh weather compensating system of heating is to be installed in the new Connecticut State Office Building at Hartford and in the palatial sixty-room residence of Harry Barnes at New Britain, Conn., according to information recently given out by the manufacturers, James P. Marsh and Company of Chicago.

The system employs automatic methods to deliver only sufficient steam to maintain a constant temperature of approximately 70 degrees, and is said to effect considerable saving in fuel consumption when weather conditions do not place full demand upon the heating plant.

•

A Note from Abroad

The following announcement has been received from England regarding the amalgamation of the Alloy Welding Processes, Ltd., and the Premier Electric Welding Company:

"Practically the whole of the issued shares of Alloy Welding Processes, Ltd., of Ferry Lane, Walthamstow, E. 17, have been purchased by Messrs, Murex, Ltd., who possess works at Rainham, Essex, and whose business is the treatment of complex ores and the manufacture of various alloys and of carbon free metals.

"Messrs. Murex, Ltd., own all the share capital of the Premier Electric Welding Company, Ltd., also that of Thermit, Ltd. The works of the Premier Electric Welding Company, Ltd., will be shortly removed to the works of Alloy Welding Processes, Ltd., as the latter company have ample space to accommodate them in their new factory, of which they took possession about eighteen months ago."

•

Service Exchange Department is to assist in building up strong distribution organizations. Use it.

THE MOST IMPORTANT INGREDIENT IN YOUR PIPE COATING IS

EXPERIENCE

The best solution to any of the problems that come up in the business of coating pipes is knowledge. Robertson has the knowledge. The H. H. Robertson Co. is the world's largest producer of special asphalts. It has made investigations in the action of soils on coating materials. It can determine the exact combination of asphaltic bases that are best calculated to protect your pipe under any given set of conditions . . . and it can produce exactly that combination.

Specify Robertson coatings on your pipes.

H. H. ROBERTSON CO.,
PITTSBURGH, PA.

ROBERTSON HAS THE EXPERIENCE

A Real "He-Man" Pump for Contractors

—*A Quality and Low Price Combination*

Absolute Self-Priming from a dry start—no need to carry water to help prime

High Suction Lift 27 ft. Maximum

Automatic or Manual Control Priming

Popular Size— 4″ or 3″ Suction— 3″ Discharge

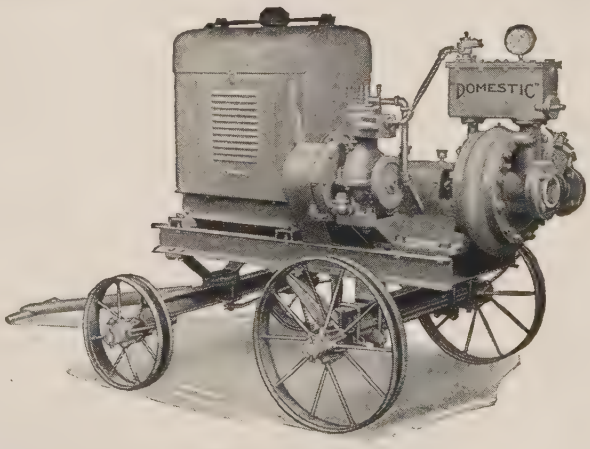


Fig. 857—VC-3T Unit

Ball Bearing Shaft —Extra Heavy

Open-passage, Wide Trash Handling Impeller —special design

Ample Power—10 hp. 4 cyl. Radiator-cooled Engine

Extra Large Capacity —425 g.p.m. on 15 ft. total head

The only Contractors' Pump having all these high-grade features ever offered at such a low price—

$600.00 plus freight from Shippensburg, Pa.

Carried in stock by Distributors in principal cities throughout the U. S. A.
Write today for descriptive bulletin and name of nearest dealer.

DOMESTIC ENGINE & PUMP CO., Manufacturers, Shippensburg, Pa.

W. H. Searight Joins Sales Force of Joy Mfg. Company

Mr. William H. Searight, for several years with the American Gas Accumulator Company as western manager, has recently joined the staff of the Joy Manufacturing Company, Franklin, Pennsylvania, as assistant sales manager in charge of snow loading and surface material handling development.

Mr. Searight, it is said, will devote his entire time to the development and sale of surface loaders carrying the Joy gathering device now used in under ground coal mines.

Hanson Made Paradon Export Manager

Announcement has been made of the appointment of Mr. Wilmer C. Hanson as export manager for the Paradon Manufacturing Co. of Arlington, N. J., makers of water purification equipment.

Mr. Hanson has been engaged in the export business all his life, specializing in engineering and water works specialties. He was formerly connected with George Nolan & Co., exporters of engineering equipment to South America. In his new position he will be located at 30 Church St., New York City.

Announcement

Mr. Stuart R. Ives, vice president and general manager of the Lyle Culvert & Pipe Company, Minneapolis, has been appointed general manager of the Armco Culvert Manufacturers Association, with headquarters at Middletown, Ohio.

Mr. Lyle comes to his new position with a background of many years of intimate contact with the culvert industry and with the problems of the road builder, the public official and the engineer in charge of drainage work.

In announcing the appointment of Mr. Ives, the Armco Culvert Manufacturers Association states that the aims and policies of the association will continue to be: "Thorough-going research in all matters pertaining to drainage, engineering assistance in the solution of specific drainage problems and educational publicity to bring the results of the association's work to the attention of those who can profit from it."

Cutler-Hammer Announces Merger

Announcement has been made by Cutler-Hammer, Inc., Milwaukee, Wis., of the acquisition of Schweitzer & Conrad, Inc., Chicago, manufacturers of high voltage equipment.

Mr. Beverly L. Worden, president of Cutler-Hammer, has been elected president of Schweitzer & Conrad, which is the only personnel change resulting from the merger. It is stated that the company purchased will continue to operate as an independent manufacturing and selling unit.

In adition to Mr. Conrad and Mr. Schweitzer continuing as members of the Board of Managers, Mr. F. R. Bacon, Mr. F. L. Pierce and Mr. Louis A. Lecher, all members of the Cutler-Hammer board, now become members of the board of Schweitzer & Conrad.

Hercules Modernizing Carthage Plant

Nine new buildings, modern in design and equipment, are to replace thirteen small buildings in the Carthage plant area of the Hercules Powder Company, according to recent announcement. Estimated cost of improvements is placed at $175,000. Removal and installation of material and machinery will account for much of the cost incurred.

It is stated that contracts will not be awarded because of the company's ruling regarding the number of men working in explosive areas. Installation is being carried out by Hercules employes under the direction of plant superintendent, J. S. Marks of Carthage, and construction engineer, R. K. Hallett of Wilmington, Delaware.

Army Officer Joins Budd

The Edward G. Budd Manufacturing Company, of Philadelphia and Detroit, makers of all-steel bodies and body parts, announces the appointment to its Detroit sales force of Colonel George A. Mix. At the close of the war Colonel Mix resigned from the regular army and has since been connected with the Auburn Automobile Company and the Chrysler Motor Company.

T. A. Burns Joins Harnischfeger Co.

Mr. T. A. Burns, who has had wide experience in selling the larger sizes of excavators, has joined the sales organization of Harnischfeger Corporation. He will work directly out of the general sales department in the home office at Milwaukee.

The Buhl Company, manufacturers of the Buhl portable air compressor, is pleased to announce the appointment of the H. O. Penn Machinery Company, 140th Street and East River, New York, as distributors in the New York district.

The H. O. Penn Machinery Company carries a complete line of these compressors and parts in stock. They will give the usual Penn service.

G. H. Williams Company announces the appointment of Kratz & McClelland of San Francisco as agents for the northern California territory. Complete stocks will be carried by the distributing company. The Williams Company is located at Erie, Pa., where the "Champion" buckets and "Arch-Girder" trailers are manufactured.

Hercules Motors Corporation of Canton, Ohio, reports a nice business on engines in Japan, where K. Hattori & Company, Limited, of Tokio serves as exclusive representative on Hercules products.

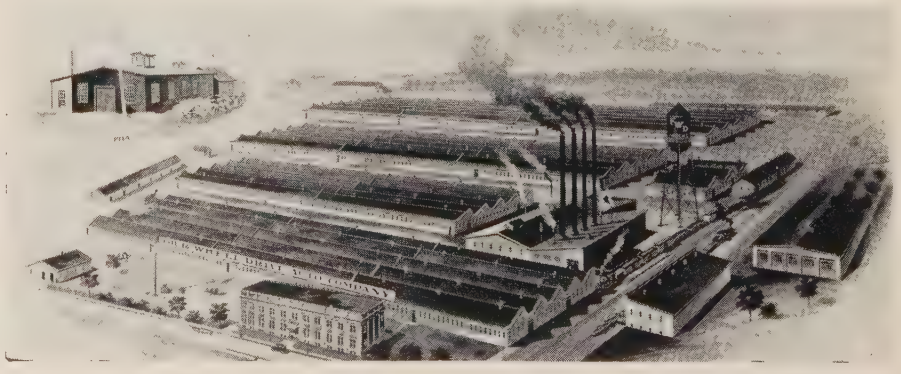
C. H. Redman Joins FWD Staff

Mr. Charles H. Redman, formerly with the Ferro Machinery and Foundry Company, Cleveland, Ohio, has joined the Four Wheel Drive Auto Company's engineering staff to devote his time to the study of adaptation of their trucks to special and unique services. Mr. Redman is a graduate of the Michigan School of Mining Engineering at Houghton.

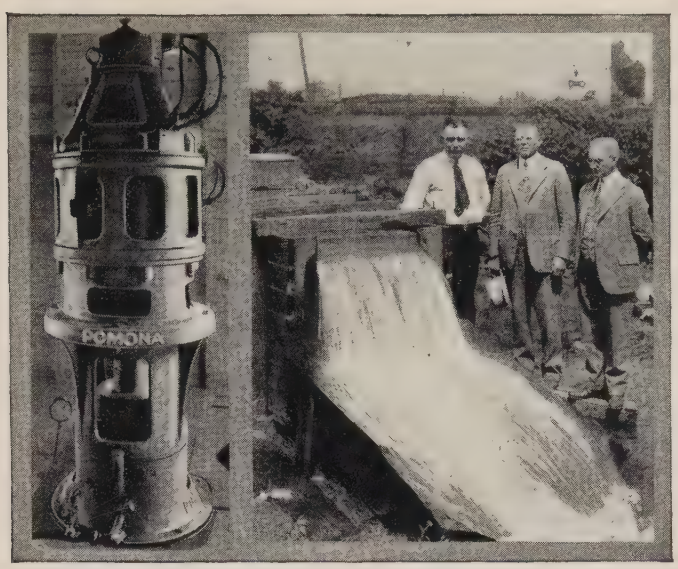
Announcement

Mr. A. Manzone has been elected president of the Rich Art Color Company, Inc., of New York City, according to recent announcement. For many years past Mr. Manzone has managed the American sales office of Pelican Works, manufacturers of drawing inks and artists' materials. The Rich Art Color Company, under Mr. Manzone's management, will continue the sale of the Pelican products.

Service Exchange has been helpful in securing desirable representation for the products of many manufacturers and in assisting distributors in building up their lines. Do not hesitate to make use of this service which the publishers present as a regular feature of this magazine. For information write, Editor, Distributor News.



1930 plant at Clintonville, Wis., headquarters of FWD Auto Co., showing increase since 1910



Pomona Turbine Pump installed for the City of Joliet, Illinois.

last month...

48 Municipalities SELECTED POMONA PUMPS

Health and sanitation are but two of many reasons why 48 municipalities purchased Pomona Turbine Pumps last month. City engineers everywhere have conceded that water-lubrication is superior for municipal water production. In response to an inquiry one director of the health department in a large American city states in part: "We are of the opinion that submerged oil-lubricated bearings should not be used in connection with drinking water supplies." Goodrich Cutless Rubber Bearings with water-lubrication is standard Pomona construction. Complete specifications and Bulletins sent on request.

Distributors and sales-service offices in all principal cities, write for name of nearest one.

Pomona Pump Co., Pomona, Calif.

POMONA

WATER LUBRICATED TURBINE TYPE

Oceans of Water

PUMPS

[Ask for Catalog]

These Sludge Bed Enclosures Join the Floral Business After 13 Years Service With the City of Alliance Ohio

A Bigger Range of King Enclosures Takes Their Place in the New Alliance Disposal Plant . . . "In Splendid Condition," Says the New Owner About the Used Range

To meet the needs of an ever-swelling population, the City of Alliance found it necessary to abandon the sewage disposal plant built in 1917 and construct a larger one in a new location.

Larger sludge beds were needed, and a bigger range of Kings to cover them. . . . And were the old Kings junked?

Never! A prominent Alliance florist bought and added them to his range. Every house was in first-class condition despite the long service under strenuous conditions.

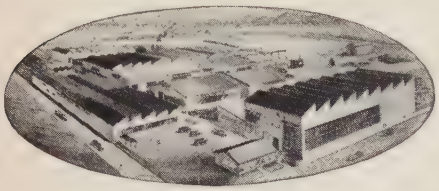
The new King Enclosures in the recently completed Alliance Disposal Plant are veritable models—solving the odor objection and more than doubling the capacity of the beds. Do you want the story describing the Alliance plant in its entirety? Write. (Literature will be included.)

KING CONSTRUCTION COMPANY
533 Wheatfield Street
North Tonawanda, N. Y.

NEW YORK CITY PHILADELPHIA, PA. BOSTON, MASS.
SCRANTON, PA. TOLEDO, OHIO SCHENECTADY, N. Y.
BRIDGEPORT, CONN.

National and International Distribution Announced for Madsen Iron Works

Until now the Madsen Iron Works, makers of portable asphalt plants, has confined its operations to west of the Mississippi, but announce negotiations are now in progress for establishing adequate representation in the principal European centers, and sufficient interest in their eastern plants to justify plans for national distribution.



The Madsen Iron Works, Huntington Park, Calif.

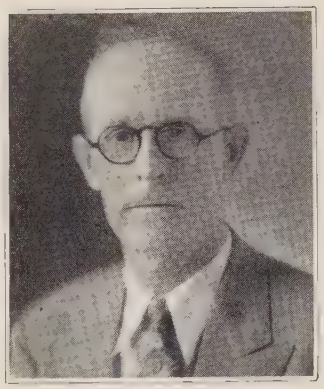
Twenty years ago Martin and Peter Madsen established their first iron foundry on a leased city lot with fifty feet of frontage. Today the Madsen Iron Works occupies its own site of five acres in Huntington Park (a suburb of Los Angeles), California, and the original staff of six people has grown to 200. It is said that the building of the first Madsen plant was the work of almost a year, whereas today a complete 1,000-lb. plant can be turned out in from three weeks to thirty days.

During the first ten years this organization engaged in making units for "stick" plants, but in 1920 they built their first complete, all metal, wholly portable plant bearing their name. This first plant was of 1,000-lb. capacity, according to Western plant rating, and was purchased by the

K. A. Richardson, Sales Manager

Southwest Paving Company of Los Angeles. Today this manufacturer is making portable tower plants in capacities up to 6,000 lb. per batch. Distribution of these plants is now reported not only in North and South America but in far away Russia.

The Madsens are said to have patented and retained control over many features of their paving plants. Mr.



Mr. Martin Madsen, President, Madsen Iron Works

Martin Madsen, president of the company, is chief of the paving plant division. K. A. Richardson, a graduate engineer, is sales manager, and A. H. Ziegler, chief engineer.

A. H. Ziegler, Chief Engineer

Distributing companies include: Edward R. Bacon Company, San Francisco; Western Road Machinery Company, Portland, Ore.; Olympic Machinery Company, Seattle; Stannard Machinery Company, Salt Lake City, Utah; H. W. Moore Equipment Co., Denver, Colo.; Wm. H. Ziegler Co., Inc., Minneapolis, Minn.; George W. Smith Company, Dallas, Texas; W. R. Grace & Company, operating throughout South America, are at present their most important foreign distributors.

Notes from House Magazines

The most recent "Sauerman News" to reach us might almost be called the "foreign edition," for it contains some interesting stories about installations of slackline cableways and scrapers for meeting excavating and materials handling difficulties in England, New Zealand and Brazil. So, with the references to construction work in our own Black Hills in Wyoming, four continents are visited and interesting pictures accompany each story.

The work in England and the British Colonies was under the direction of the English engineer, Mr. E. F. Sargent of Skelton, York.

The South American stories concerned the work of the Bahia Corporation in diamond-bearing gravel to secure carbonado, or black diamonds used for drills and other important industrial uses. This is an American corporation formed in New York by Arthur S. Bandler, who serves as president. David Bandler is vice-president and treasurer, Thomas J. Ward, secretary, and A. P. Rogers, a mining engineer of long experience, is general manager.

The construction work as described at Bahia was in charge of A. D. Hughes and a staff of expert assistants, among them Harold D. Douglas, John Moline, who had charge of erection and installation of cableways, and Simpson Watt of the Westinghouse company, in charge of electrical installations.

This interesting story was told in the "Sauerman News," published by Sauerman Bros., Inc., Chicago.

* * *

Pipe information historically told is the way of the little U. S. Piper, of the United States Pipe & Foundry Co., and it makes fascinating reading both concerning the cast iron pipe and the history. For what's being done in the East read about the old traditionally interesting town of Frederic, Md., if longing for the wide open spaces Durango, Col., installs a model water system and takes its pure water from the Rocky Mountain snow fields. That isn't all the Piper talks about either and it's all good reading.

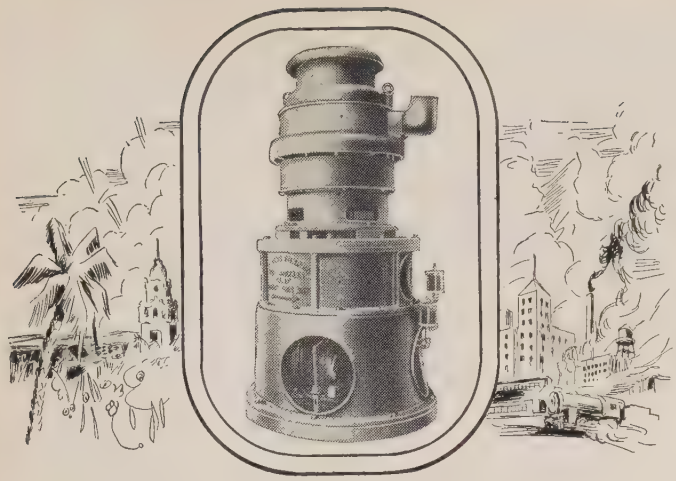
* * *

"All dressed up" were the Schramm compressors shown in the last "Bores and Strokes" from West Chester, Pa., for they appeared surrounded by ferns and hanging flower baskets in the booth of the Metal Union Ltd. display at Public Works Exhibition, Agricultural Hall, London, England.

* * *

Some of us know about old clothes turned inside out, and "turning clouds about to see the lining" has been told in song and story, but turning pavements upside down is something else again. "New Pavements from Old" is the title of an article by Herman Geiser telling of turning brick pavements over for the city of Lima, O. It appeared in "Dependable Highways," the publication of the National Paving Brick Manufacturers Association of Washington, D. C.

International Filter Co. and associated companies, International Water Softener Co. and General Zeolite Co. announce the removal of their general offices and engineering departments from Plant No. 1 at 333 W. 25th Place, Chicago, to larger quarters covering the 13th and part of the 14th floor of the Buckingham Building, at 59 E. Van Buren St. The change was made in order to increase manufacturing facilities.



The Choice of Cities

Dependable water supply being highly essential to municipalities, it is only natural that so many of the city engineers, who have thoroughly investigated the functions dependent upon efficient pumps, should specify PEERLESS to insure satisfactory service with the least maintenance expense.

Illustrated literature free upon request. No cost or obligation—just write Department W.

Peerless Pumps

YOU CAN ALWAYS DEPEND ON A PEERLESS—ALL WAYS

PEERLESS PUMP COMPANY

Executive Offices: 1902 E. 67th St., Los Angeles, Calif.
Factories: Los Angeles, Calif., Massillon, Ohio
New York Office: Room 513, 51 E. 42nd St. Massillon Office: 302 Walnut Avenue, S. W. Chicago Office. Room 410, 9 So. Clinton St.
DISTRIBUTORS IN ALL PRINCIPAL CITIES

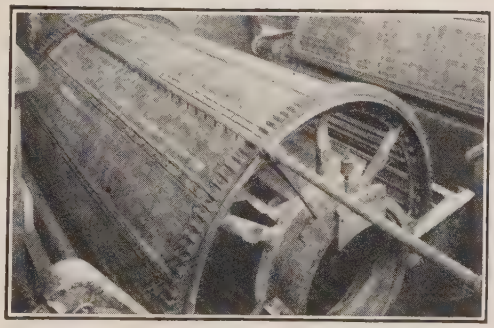
It's what you get out of them
THAT COUNTS

You can buy tool boxes *and* tool boxes. The thing uppermost in your mind is, "Will this tool box serve our purpose?" If you intend to purchase one tool box or a lot of them, by all means, let us send you a full description of our new All-Steel Utility (Splicer) Box—made for water works maintenance departments. Compare it with other boxes.

LB STEEL BOXES FOR EVERY PURPOSE LITTLEFORD BROS. CINCINNATI

LITTLEFORD
ALL-STEEL
TOOL BOXES

LITTLEFORD BROS. 422 E. PEARL ST. CINCINNATI, O.



At Plankington plant

The North Sewage Screen

A clarifier which removes and aerates the effluent. Liquids go through perforations finer than a cambric needle.

Saves byproducts in a dry state.

Doubles capacity of old sewage plants. Decreases cost of new disposal plants.

Is all you need if effluent discharges into large streams.

The only *fine* screen on the market.

GREEN BAY FOUNDRY & MACHINE WORKS
GREEN BAY, WIS.

"NO VISIBLE SOLIDS IN EFFLUENT"

POWERFUL
POSITIVE-PRACTICAL

Ideal for colder climates. Protects meters from freezing.

Single Lid Cover for milder climates where less protection is necessary. Neat, unobstrusive.

There are 25 types and sizes of Ford Meter Box Covers—All have The Ford Worm Lock.

It locks the lid securely—
It lifts the lid on unlocking—

Hundreds of thousands are in service.

Write for Catalog

The FORD METER BOX Co.
WABASH-INDIANA
WATER METER SETTING & TESTING EQUIPMENT

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Manufacturer's representative now handling centrifugal pumps would like to secure other lines in water works field. Covers eastern Pennsylvania, south Jersey and Delaware.

Water Works equipment distributor, covering northeastern Indiana, would like to secure represenation of a line of chlorinators.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Bacteriologist would like to make connection with manufacturer for such work, or as assistant chemist.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

West Coast distributor, specializing in materials for sewers and water works, is in a position to render splendid representation for territory covered.

Manufacturer's representative, with warehouse facilities available, would like to secure additional lines in water works and sewerage and general contracting fields. Covers Houston and San Antonio territory.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Distributor of building specialties covering a territory of 100 mile radius from Chicago is equipped to represent additional lines.

Manufacturer's representative, covering Massachusetts, Rhode Island and southern New Hampshire, would like to secure line of speed reducers and gears.

Manufacturer's representative with 25 years sales experience, conversant with all types of pumps and their field, desires agency for either New York or export territory, or both.

A Michigan distributor, with many years' experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing increased facilities in this region.

Representatives Wanted

Manufacturer of special valve and hydrant lubricant wishes to establish distributing points throughout the country.

Manufacturer of centrifugal pumps for water works, sewage plants, sand and dredging plants, process industry, contractors, etc., desires to secure additional representation. Attractive territory available.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Attractive territory available for experienced men to handle contractors' labor-saving equipment by old established company. Equipment backed by national advertising.

Manufacturer of complete line of construction equipment, mixers, saw rigs, plaster and mortar mixers and pumps has an open territory in the state of Maine and is looking for an aggressive distributor to represent him there.

Long established and well-known manufacturer of industrial locomotives wishes to make contacts with qualified distributors. Locomotive line includes steam, gasoline, gas-electric and oil-electric. Supported by national trade journal advertising.

Manufacturer of air compressors and contractors' tools has number of desirable territories open. Full co-operation will be extended to distributors.

Distributors wanted to represent improved type of snow fence. Good territory in various parts of country.

Manufacturer of contractors and builders levels and transits is seeking district sales manager. Exclusive contract given. Excellent territory still available. Backed by national advertising.

One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

Manufacturer of metal tie and spacer wishes to establish distributing points throughout the country.

Machines desires to build up distribution organization in this country and abroad.

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Power Plant Development Launched by Union Carbide & Carbon Corp.

Construction work is now under way on new hydro-electric and steam electric power plant developments of Subsidiary Companies of Union Carbide and Carbon Corporation, in the vicinity of Hawks Nest, Gauley Junction and Boncar, West Virginia. The total installed capacity of the two plants will be about 200,000 hp. Power output will be utilized by the proposed industrial plant of Electro Metallurgical Company at Boncar.

The hydro-electric power development is being built by New-Kanawha Power Company and is located on the New River, between Hawks Nest and Gauley Junction. It will consist of a dam across New River, an intake, a power tunnel, surge tank, steel penstocks and power house.

The contract for the construction of the dam, tunnel and power house was let to Rinehart and Dennis Company, Incorporated, on March 13, 1930, and work was commenced on March 30. Completion is required and the entire development is expected to be ready for operation by March 13, 1932.

The steam electric power plant is being built by West Virginia Hydro-Electric Company on the Kanawha River immediately adjacent to the site of the industrial plant at Boncar. The contract for its design and construction was let to Ford, Bacon and Davis, Incorporated, on April 15, 1930, and it is expected that it will be finished about July 1, 1931.

The hydro-electric and steam electric plants are expected to provide an average combined annual output of about 120,000 hp.

Mr. O. M. Jones, chief engineer of New-Kanawha Power Company, who is located at Glen Ferris, West Virginia, is in local charge of the hydro and steam plant installations for Mr. L. H. Davis, 30 East 42nd Street, New York, N. Y., vice-president of New-Kanawha Power Company and West Virginia Hydro-Electric Company. Mr. E. H. Mangen is resident engineer in charge of the industrial plant installation for Mr. H. L. Noyes, chief engineer of Electro Metallurgical Company, who is located at Niagara Falls, N. Y. Contract for the erection of the first block of industrial plant buildings has been let to H. B. Agsten and Sons, of Charelston, West Virginia.

Ground breaking ceremony at Hawks Nest, West Virginia, as steam shovel turned the first bucketfull of earth in the hydro-electric power development now under way for the Union Carbide and Carbon Corporation

Byers Announces Changes in Personnel

H. W. Rinearson, vice-president of A. M. Byers Company has announced several changes in the organization personnel.

H. R. Rowland, division manager at Philadelphia, has been transferred to Pittsburgh as division manager.

E. L. MacWhorter, representing A. M. Byers in western New York, has been promoted to division manager with headquarters in Philadelphia.

Early in October the company will hold a national sales meeting in Pittsburgh. This meeting will be held in conjunction with the official opening of the company's new $12,000,000 plant for manufacturing wrought iron under the Aston patents.

News Notes from Paradon

The Paradon Manufacturing Company of Arlington, N. J., announces the appointment of S. S. Williamson as manager of advertising and publicity for the company. Mr. Williamson has spent his entire business efforts in the advertising field and for several years was publicity and advertising manager of the Lidgerwood Company of Elizabeth, N. J.

W. Austin Smith, 1207 Lynch Building, Jacksonville, Fla., has been made sale and service representative for the Paradon chlorinators in Southern Georgia and Northern Florida.

General Engineering and Equipment Company, 704 First National Bank Building, Albuquerque, N. M., has been appointed to represent the Paradon products in the state of New Mexico.

West Virginia will be served for this manufacturing company by Kanawha Equipment, Inc., of Charleston, W. Va.

Announcement

Ray P. Tarbell has recently become a member of the firm of Robert E. Kinkead, Inc., consulting welding engineers, Cleveland, Ohio. He was formerly Cleveland District Sales Manager of The Lincoln Electric Company, manufacturers of Stable-Arc welders and Linc-Weld motors.

Robert E. Kinkead, Inc., serve as welding engineering consultants for large steel companies, steel fabricators and manufacturers of mechanical equipment. They also supervise the establishment of welding departments within industrial firms and direct the methods of welding procedure and control and the redesign of products for arc welded steel construction, a field in which Mr. Tarbell in his former capacity has been actively engaged for many years. As vice president and secretary, Mr. Tarbell will aid Mr. Robert E. Kinkead, well-known authority on welding procedure and control, in his executive duties as president of the firm which bears his name.

Mr. Tarbell, who attended Dartmouth College, entered the employ of The Lincoln Electric Company in 1918.

Shell Chemical Company at Martinez, Cal., is installing E-M Synchronous Motors in the new nitrogen fixation plant to drive air, raw gas, mixed gas and ammonia compressors. All the gas compressors will be equipped with gas-proof enclosures for the collector rings because of the gaseous atmosphere in which the motors are to operate. The control equipment will consist of the E-M full-voltage, automatic controls for synchronous motors. Equipment is furnished by the Electric Machinery Manufacturing Co., Minneapolis.

Tubular Sales Manager for A. M. Byers Co.

Sales activities for the A. M. Byers Company are being departmentalized because of the proposed expansion program looking to the broadening market for the use of wrought iron in forms other than pipe, according to announcement of H. W. Rinearson, vice-president. A newly created position is that of manager of tubular sales which has been assigned to M. J. Czarniecki.

Mr. Czarniecki has been connected with the Pittsburgh, New York and Chicago offices of Byers, and has served them continuously, with the exception of the period of the war, since 1913. Since 1925 he has been serving as assistant general manager of sales with headquarters in Pittsburgh.

Burton Explosives Enters Manufacturing Field

Concurrent with the filing of a deed covering 418 acres of land near New Castle, Pa., announcement is made of the entry of Burton Explosives, Inc., hitherto a sales organization, into the explosive and chemical manufacturing field.

J. S. Burton, president and general manager, formerly president of The Grasselli Powder Company, is quoted as stating that an initial production of 12,000,000 pounds of high explosives in 1931 is projected.

A plant to employ over one hundred men is now under construction on the site of the former American High Explosives Company, of which Mr. Burton was general manager at the time of a merger of The Burton Powder Company with Grasselli in 1917.

Manufacture of a line of heavy chemicals is proposed as a development to follow the establishment of the explosive line.

Headquarters of the company are in the Guardian Building, Cleveland, Ohio.

Production is scheduled to start January 1, 1931.

X-Ray Plant Installed for Babcock & Wilcox

The St. John X-Ray Service Corporation, 505 Fifth Avenue, has installed what is said to be the first X-Ray plant of its kind in the Barberton, Ohio works of the Babcock & Wilcox Company.

The photographic apparatus will be used primarily for routine inspection of welded seams in pressure vessels, heat exchangers and similar equipment.

Dr. Ancel St. John, president and technical director of the company which bears his name, says that the Babcock & Wilcox X-Ray plant is certainly the first of its kind and in all probability, the most powerful as well.

Westinghouse Promotes T. R. Langan

C. E. Stephens, vice president, Westinghouse Electric and Manufacturing Company has announced the appointment of T. R. Langan as assistant northeastern district manager of the Westinghouse organization.

Mr. Langan has been with the Westinghouse Company for more than twenty years. Starting as an apprentice he advanced to the office of manager of the transportation division of the northeastern district, which office he held at the time of his promotion. He has been identified with the major high voltage A.C. railroad electrifications in the United States, and when the New York, New Haven & Hartford Railroad system was electrified, Mr. Langan acted in a supervisory capacity on this installation for seven years.

T. R. Langan

Before coming to the New York office, Mr. Langan served the Westinghouse Company in Philadelphia, Baltimore, Buffalo and was manager of the Syracuse office.

Mr. Langan will make his headquarters at New York and will continue to function as manager of the transportation division of the northeastern district.

Link-Belt Transfers MacNeal to Birmingham

B. H. MacNeal, who has been with the Link-Belt for a number of years, has been appointed Southern District Manager of the crane-shovel-dragline division. He has had a broad experience both at factory and in the field, with the complete line of Link-Belt products.

Mr. MacNeal will have charge of the territory between the Mississippi Valley and the east coast, south of and including the states of Tennessee and North Carolina, and will maintain headquarters at the company's Birmingham office.

Electricity Did It

Forty seconds for wood pulp and water to pass through approximately ten individual machines and come out a sheet of paper ready for the printer's ink, is the time specified by E. L. Manning of the Research Laboratory of the General Electric Company. Just one more debt of gratitude that the public owes to the power of electricity.

Mr. Manning is presenting a series of sketches outlining various research and engineering achievements of the electrical industry, which are being broadcast over WGY.

The Independent Pneumatic Tool Company, 600 West Jackson Boulevard, Chicago, has appointed the Mine and Smelter Supply Company, Salt Lake City, Utah, as their agent. This company will handle a complete line of Thor Pneumatic and contractor tools in their territory. They have branch offices in Denver and El Paso.

Keystone Portland Cement Elects Scott President

Announcement has been made by the Keystone Portland Cement Company of the election of Harold M. Scott as president to fill the vacancy caused by the death of the former president, John Barnes.

Although Mr. Scott may be considered one of the younger men in the industry, his experience covers a period of 25 years. He has been connected with the Lehigh, Edison and Atlas Portland Cement Companies. He was general sales manager of the Atlas company, and according to report will adopt a policy of aggressive operation for Keystone.

Construction of the two additional kilns, grinding equipment and storage facilities, which were inaugurated about a year ago at the Bath, Pennsylvania, works of Keystone have been practically completed, which is said to make this plant one of the largest single units in the Eastern territory.

Hercules Powder Makes Personnel Changes

Mr. C. C. Gerow, director of sales of the Hercules Powder Company of Wilmington, Delaware, has announced the appointment of J. H. Horlick, Jr., as assistant director. Mr. Horlick has served for a number of years as manager of the service division. He will take over the duties of the late Fred F. Smith.

J. Barab will become new service division manager, and H. M. Lynch will continue to act as chief clerk and as assistant to Mr. Horlick, according to announcement.

Changes in Boston Office Of Penn-Dixie Cement

According to recent announcement, H. E. Bernt has been appointed district sales manager of the Boston office of the Pennsylvania Dixie Cement Corporation. He takes over the office held by E. G. Brick, who, according to report, asked to be relieved of the responsibilities in connection with it and will thus be able to make more frequent contacts with the trade.

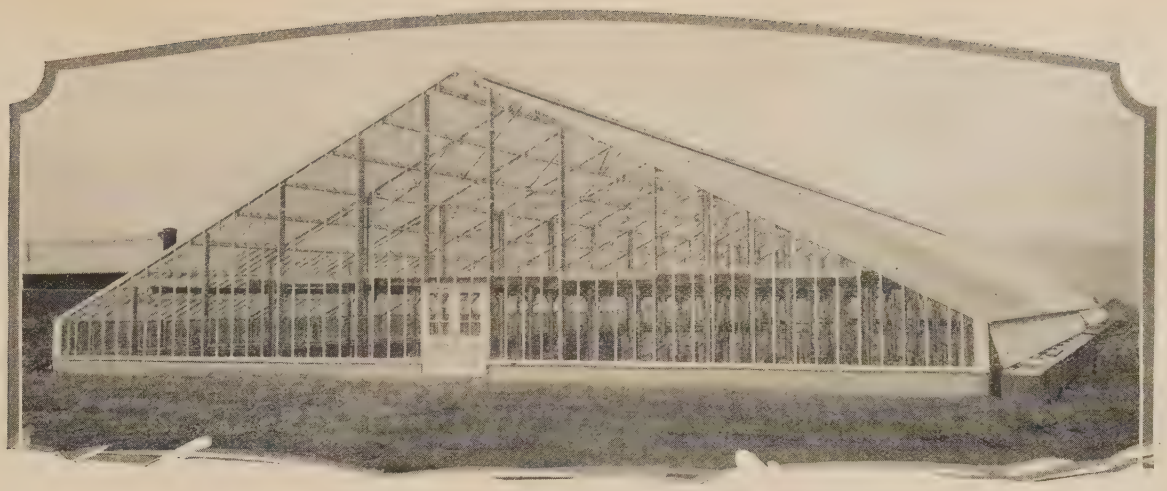
Mr. Bernt is familiar with the territory and its requirements as for some time past he has been assistant district sale manager.

The position of assistant district sales manager of the Boston office will be filled by R. M. Penman, who has recently joined the Penn-Dixie organization. Mr. Penman has been connected with a leading cement manufacturer for the past 21 years.

Hercules Powder Executives Attend European Meeting

George M. Norman, technical director of the Hercules Powder Company, and A. B. Nixon, general manager, Cellulose Products Department, left recently for Europe where Mr. Norman will attend the International Cellulose Conference at Liege, Belgium. Mr. Nixon will survey the market for American collodion cotton in Germany and other countries.

Service Exchange Department is to assist in building up strong distribution organizations. Use it.



Moore erects all-steel glass sludge bed enclosures for City of Dunkirk

Since 1869

THE Moore Construction Co. of Buffalo, New York, have just completed the erection of two American-Moninger all-steel acid resisting glass sludge bed enclosures for the City of Dunkirk, New York. One house is 74 feet wide by 125 feet long and the other is 74 feet wide by 250 feet long. Frederick K. Wing Company of Buffalo, New York, were the engineers.

These houses were designed and built with heavy overhead beams arranged for carrying the Louden Buckets used in sludge bed work.

Benefit from American-Moninger's experience in sludge bed work and get preliminary plans, specifications and estimates from American-Moninger before you build. No obligation on your part.

American-Moninger Greenhouse Manufacturing Company

SOUTHWEST OFFICE
2611 North Dewey St.
Oklahoma City, Okla.

1365 Flushing Avenue
Brooklyn, New York

WESTERN OFFICE
1313 W. Randolph Street
Chicago, Ill.

No Water Hammer—No Bursted Mains

GOLDEN-ANDERSON

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Float Valves

Adapted to automatically maintain a uniform water level in feed-water heaters, tanks, reservoirs, and pans. Very sensitive.

Operating on ½-inch to ¾-inch variation. No exhaust or expensive water waste. Can be furnished for hot or cold initial water supply. Reliable and dependable under varying pressure.

Sizes ½-inch to 24 inches

Automatic "Cushioned" Controlling Altitude Valves Cushion All Water Surges

Automatically maintain a constant stage of water in reservoirs, tanks and standpipes. They do away with the annoyances of Freezing Valves and Float fixtures inside of the Tanks or Floats and Fixtures outside of Tanks.

"Three Ways of Closing These Valves":
1st—Automatically, by water.
2nd—By electricity, if desired.
3rd—By hand.

May also be arranged to close automatically when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe. The double cushion effect of air and water eliminates water hammer. There are no dangerous surges to burst water mains. Write for details.

REMEMBER
Valves cushioned at all times by air and water. No water hammer or bursting mains.

"Made with stop starter attachment for centrifugal pumps."

GOLDEN-ANDERSON VALVE SPECIALTY COMPANY
1329 Fulton Bldg., Pittsburgh, Pa.

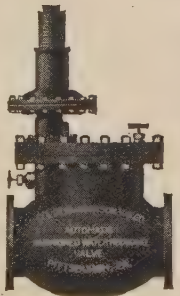
GOLDEN-ANDERSON

Patent Cushioned Water Relief Valves

1. Automatically relieve excess pressure.
2. Prevent stress, strain and bursting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and globe pattern. Sizes 3 to 24-inches.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Pressure Regulating Valves



1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

GOLDEN-ANDERSON

Pat. Automatic Double Cushioned Check Valves

1. Especially adapted for water service.
2. For high or low pressure.
3. Thoroughly cushioned. No chattering, hammering, or sticking.
4. Globe or angle patterns up to 24 inches.
5. Especially adapted for hydraulic elevator service.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Float Valves

1. Automatically maintain uniform water levels in tanks, standpipe, etc.
2. Instantly adjusted to operate quickly or slowly.
3. Floats swivel to any angle—most satisfactory float valves known.
4. No metal-to-metal seats—no water hammer or shock.
5. Cushioned by air and water.

Sizes ¼" to 24".

Cast Iron Pipe Co. Hold Open House at Denver

In celebration of the opening of the new office of the Pacific States Cast Iron Pipe Company in Denver, "open house" was held October 3rd and 4th in Room 226, Continental Oil Building, Eighth and Glenarm Street.

The celebration took the form of informal discussions of water works problems and exhibits of McWane-Pacific cast iron pipe.

Dana E. Kepner is manager of the Denver office, which will serve Wyoming, Colorado and New Mexico. A complete stock of McWane-Pacific products will be available at Denver for territory covered.

General offices and foundries of the Pacific States Company are located at Provo, Utah.

Permutit Buys Zeolite Water Softening Apparatus

The Paige and Jones Chemical Company announces that it has sold to The Permutit Company the Zeolite and Lime Soda Water Softening and Filter Departments of its business including machinery, inventories, patterns and drawings relating thereto. It has been manufacturing Zeolite water softening apparatus as licensee under The Permutit Company's patents. The Permutit Company with its large engineering staff will be in a position to furnish repair parts and replacements for Paige-Jones mechanical equipment now in use. The Paige and Jones Chemical Company will continue the chemical branch of its business in which it has held a prominent position for the past sixteen years.

Penn-Dixie Announces Promotions

B. W. Druckenmiller, who for the past two years has been sales manager of the Pennsylvania-Dixie Cement Corporation, has been appointed assistant general sales manager, with headquarters at 521 Fifth Avenue, New York, according to recent announcement. Before joining Penn-Dixie Mr. Druckenmiller was connected with the Crescent Portland Cement Company, Wampun, Pa., for approximately sixteen years.

F. J. Selinger, who became associated with the Penn-Dixie organization some months ago, has been appointed sales manager. For twenty-three years Mr. Selinger was connected with the Portland Atlas Cement Company before joining the firm with which he is now associated.

Benefit by Pension Plan

Full pension benefit for their whole period of continuous service with the former Atlas Portland Cement Co., whose properties, assets, and business were acquired by the United States Steel corporation in January, will be extended to Atlas workers now continuing with the Universal Atlas Cement Co., a U. S. Steel Corporation subsidiary. This decision, according to recent announcement by the Universal Atlas Company, places in line for pension benefits approximately 4000 former Atlas employees, many of whom thus get credit for twenty-five or more years of work with the former firm.

The United States Steel Corporation pension fund, introduced in 1910 by the corporation and Andrew Carnegie jointly, was one of the first general pension plans established in American industry. Its benefits are apportioned according to a sliding scale based on wages and length of service. The new ruling means that former Atlas men will receive pension credit for continuous service including not only the period since January, but all continuous service with the former Atlas company.

The pension plan involves the retirement of men who have served twenty-five years or more, usually at age of seventy; by request, at sixty-five or thereafter; and at any age, through permanent incapacity.

Haynes Stellite Company Opens New Foundry

Haynes Stellite Company, Kokomo, Ind., a unit of Union Carbide and Carbon Corporation, has announced the completion of a new foundry at the Kokomo Works, which has been built expressly for the manufacture of the Hastelloys, a group of new acid resistant alloys. It is stated the most up-to-date and efficient foundry equipment procurable has been installed to insure careful control of quality and uniformity of product.

The Hastelloys form a group of corrosion-resistant alloys of interest to chemical engineers, and others who have been faced with the problem of providing suitable equipment for resisting the action of hydrochloric acid and moist chlorine. Hastelloy "A" resists the action of both hot and cold hydrochloric acid, while Hastelloy "C" resists the action of wet chlorine.

The production of these alloys, facilitated by the opening of this new foundry, will be of interest not only to the chemical and process industries but to all industries in which the handling of acids is a problem.

An October Date

The semi-annual meeting of the Concrete Reinforcing Steel Institute will be held from October 20 to 22, at Briarcliff Lodge, Westchester County, New York.

The American Iron and Steel Institute is to meet in New York City October 24, so members and guests may thus kill two meetings with one railroad trip.

The principal address of the opening session of the Reinforcing Institute will be made by Mr. James G. Lewis, eastern manager of the Scripps-Howard Newspapers, New York City. The subject as announced is "Where Selling Should Stop."

The committee in charge of arrangements for the Institute will provide cars for guests to motor along the Hudson River to West Point, Bear Mountain Bridge and other nearby points of beauty.

Representation on the Florida coast has been secured for the Institute through the recent election of D. F. Taylor, Inc., of Tampa, to membership, according to recent announcement.

The City of Chicago received some very interesting publicity (not a word about shooting) in the lead-off article on The Development of a Great Utility, which appeared in the September issue of The U. S. Piper, the monthly paper published by the United States Pipe and Foundry Company of Burlington, N. J. Mr. Ralph M. Shaw, Jr., is the editor of this interesting and attractive monthly.

Distributors in Far Northwest Over Twenty Years

The B. C. Equipment Co., Vancouver, B. C., who have recently taken on the distribution of McCormick-Deering tractors and the Trackson line of Crawlers, Shovels, Cranes, Hoists, etc., are one of the oldest equipment firms in the Dominion. They have been in business in British Columbia for more than twenty years and are well known to the equipment industry in the United States, as well as in Canada.

At the head of the B. C. Equipment Co. are S. J. Crocker, manager; F. A. Dietrich and G. W. Tornroos, who together organized the company and are still actively engaged in its operation. Another veteran equipment man, Norman C. Cruikshank, is the manager of their tractor and equipment department.

In addition to their main offices and showrooms at Vancouver, they also have a large warehouse and shop in the city, and a branch office at Nelson. A staff of thirty is employed at Vancouver and three men work out of the Nelson office.

These distributors are in close touch with highway and other government and municipal officials, contractors, the mining industry, loggers, etc., and are finding a very big field for the lines they represent.

In addition to the International Harvester Co. and The Trackson Co., they represent the Gardner-Denver Co., Climax Engineering Co., DeLaval Steam Turbine Co., Dominion Road Machinery Co., Ransome Concrete Machinery Co., London Concrete Machinery Co., Petters, Ltd., of England, Northwest Engineering Co., S.K.F. Steels, Inc., Sweden, and other well-known manufacturers.

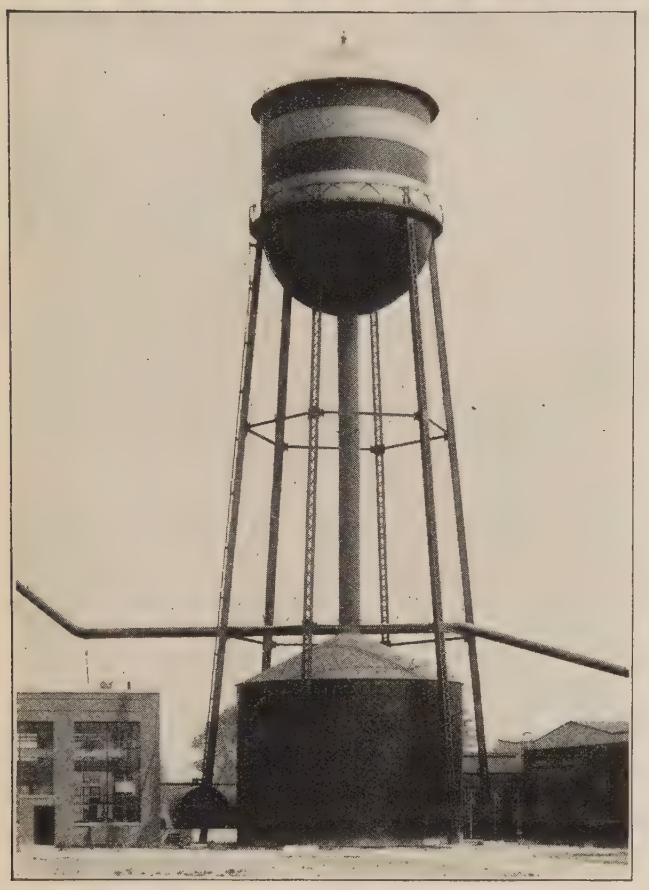
Traffic Will Be Served

The famous Tennessee Pass highway in Colorado, 10,240 feet above sea level, was kept open throughout the entire last winter for an average daily motor traffic of 100 cars. This is thought to be the first time such a record was ever maintained. Crews at times worked at a temperature of 36 degrees below zero.

Chicago Mill and Lumber Corporation announces the appointment of M. C. Jensen as successor to W. H. Badeaux in the company's northwest district with headquarters in the Foshay Tower, Minneapolis. Mr. Jensen was until recently supervisor of Weatherwild sales in the New York zone for the company he represents. Mr. Badeaux has joined Simmons Millwork, Inc., of Minneapolis.

Service Exchange has been helpful in securing desirable representation for the products of many manufacturers and in assisting distributors in building up their lines. Do not hesitate to make use of this service which the publishers present as a regular feature of this magazine. For information write, Editor, Distributor News.

PITTSBURGH DES MOINES



The 200,000 gallon PDM Elevated Tank on a 100 foot tower gives reliable fire protection to the Fisher Body Corporation plant at Seattle, Washington. The ground suction tank is also of 200,000 gallon capacity

The Elevated Tank Supplies the Pressure The Ground Tank gives the Reserve Supply

Last summer's seven weeks' drought taught municipal and industrial officials many things about water supply. Two fundamental requirements are *Pressure* and *Reserve Supply*. Each complements the other; each alone is not adequate.

Pittsburgh-Des Moines Elevated Steel Tanks today guarantee the required water pressure in all parts of the United States. Pittsburgh-Des Moines Ground Tanks and Steel Standpipes up to 3,000,000 gallons supply the necessary reserve supply to maintain this pressure during fire, drought, repairs, or other emergencies.

Thirty-three years' contracting experience in the municipal and industrial fields qualify PDM engineers and tank builders to design and erect your water supply equipment.

PDM Engineers will gladly cooperate with you in applying the economics of modern water storage and supply to your problem. Write today for our Tank and Tower Folder No. 2 giving detailed drawings and measurements of a standard PDM tank and Tower

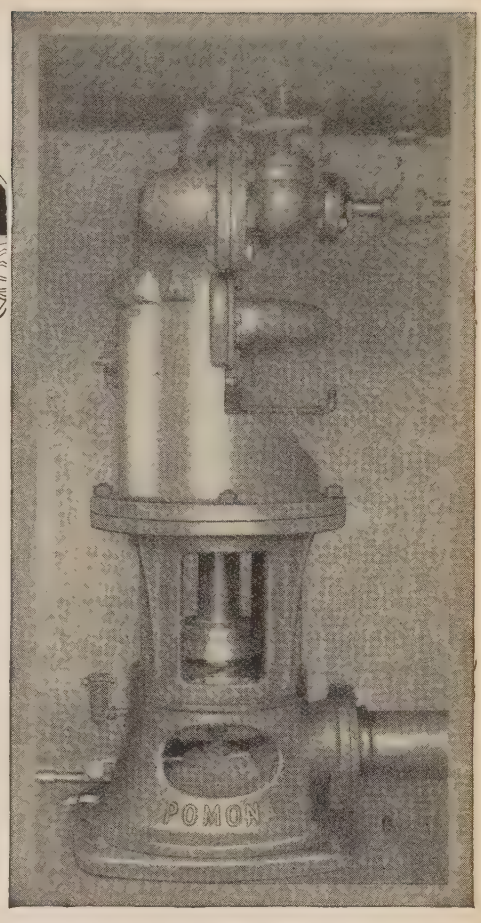
Pittsburgh-Des Moines Steel Company

3404 Neville Island, Pittsburgh, Pa.
906 Tuttle St., Des Moines, Ia.

New York Chicago Dallas Atlanta
Seattle San Francisco

Oceans of Water

Pomona Water-Lubricated Turbine Pumps are readily adapted to any prime mover. Photo at right shows a Murray Vertical Steam Turbine mounted on Pomona pump head.



Pumping Water economically with Steam or Electricity

Hundreds of satisfied WATER WORKS ENGINEERS are using Pomona Water-Lubricated Turbine Pumps exclusively. They have proven to themselves that our claim to cleanest water, more economically produced, is based on facts. In your vicinity there are Pomonas operated by many different methods; direct connected electric motors of any current characteristic, belted heads driven by tractor, steam engines, horizontal motors, etc. In many plants, where steam is available, vertical steam turbine drive is well suited. Constant attention or trained engineers are not required to operate the Pomona Water-Lubricated Turbine Pump.

Factory representatives, sales and service offices in all principal cities. Name of nearest one and Bulletin on request.

Pomona Pump Co , Pomona, Calif.

POMONA

WATER-LUBRICATED TURBINE **PUMPS**

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives of their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

West Coast distributor, specializing in materials for sewers and water works, is in a position to render splendid representation for territory covered.

Manufacturer's representative, with warehouse facilities available, would like to secure additional lines in water works and sewerage and general contracting fields. Covers Houston and San Antonio territory.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Manufacturer's representative now handling centrifugal pumps would like to secure other lines in water works field. Covers eastern Pennsylvania, south Jersey and Delaware.

Water Works equipment distributor, covering northeastern Indiana, would like to secure representation of a line of chlorinators.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

West Coast distributing organization equipped to take on additional lines of equipment and supplies for water works and sewerage field.

Water works equipment distributor, covering northeastern Indiana, would like to secure representation of a line of chlorinators.

Distributor covering Wisconsin and Illinois territory wishes to add to present lines. Thoroughly familiar with bituminous materials and equipment for handling.

Wanted line of street markers or other traffic equipment on exclusive basis by distributor covering New Jersey and New York territory.

Warehouse facilities for serving Pittsburgh territory. Would like to secure line of portable and stationary conveyors.

Representative in Northwest desires to handle, on commission basis, line of road building and maintenance machinery, revolving scrapers, tractors, rotary snow plows and V push plows.

Good, unassigned territory available for distributors and manufacturer's representatives to handle paving expansion joint line.

Diesel engine account, road building material and equipment line, and industrial equipment and materials seeking representation in south wanted by Florida distributor. Large warehouse facilities.

Representatives Wanted

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Manufacturer of centrifugal pumps for water works, sewage plants, sand and dredging plants, process industry, contractors, etc., desires to secure additional representation. Attractive territory available.

Manufacturer of special valve and hydrant lubricant wishes to establish distributing points throughout the country.

Eastern manufacturer of grade-rippers, scrapers and road hones has desirable territory open for distributors.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

California territory available for distributor wishing paving expansion joint account.

Southwest and Middlewest distributors wanted by manufacturer of metal lath, corner beads, channels and reinforcing mesh.

Manufacturer of complete line of construction equipment, mixers, saw rigs, plaster and mortar mixers and pumps has an open territory in the state of Maine and is looking for an aggressive distributor to represent him there.

Long established and well-known manufacturer of industrial locomotives wishes to make contacts with qualified distributors. Locomotive line includes steam, gasoline, gas-electric and oil-electric. Supported by national trade journal advertising.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

Manufacturer of metal tie and spacer wishes to establish distributing points throughout the country.

Attractive territory open in states south and west of Chicago by manufacturer of cut to length, easily erected standardized steel highway bridges, for spans up to and including 40 ft. Product sells to highway commissioners and superintendents.

Manufacturer of Transverse Testing Machines desires to build up distribution organization in this country and abroad.

Several desirable states open. Wanted distributing organizations covering entire states by manufacturer of mechanical spreader.

Territory open in several states for representatives to handle grade-rippers, scrapers and plows.

Open territory in New York and New England states for aggressive distributor wishing to take on line of hoisting machinery and air compressors.

Manufacturer of air compressors and contractors' tools has number of desirable territories open. Full co-operation will be extended to distributors.

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

U. S. Pipe & Foundry Opens New Laboratories

The United States Pipe and Foundry Company is taking much justifiable pride in the opening of the new research laboratories, and recently conducted an inspection trip through the various departments for representatives of the trade paper press.

Every department was visited with the greatest interest and demonstrations and exhibits of apparatus and machines gave forceful testimony to the completeness of this new addition to the facilities of this organization.

In the Mettallographic Laboratories equipment was shown for examining the structure of metals up to several thousand diameters, and all accessories for rapid work such as printing machines, drying and washing machines, to enable the preparation of reports requiring photographic prints in a rapid and economical manner.

Studies are being made by the laboratories to develop better cement coatings with the entire elimination of free lime and a complete apparatus was exhibited for the study of cement in connection with the study of centrifugal lining of pipe.

The Sand Testing Department was visited where a method for determining moisture in sand by means of electrical and air currents was shown, and the strength and permeability of dry and green sand cores was also demonstrated.

The Chemical Department and the Physical Laboratory were filled with points of interest. The Physical Department has been so laid out that specimens can be machined promptly and results obtained with a minimum delay.

The following is a list of equipment to be found in the Physical Laboratory.

Test Machines

1. 50,000 lb. Amsler Universal Testing Machine.
2. Tinius Olsen Izod Impact Testing Machine.
3. One Inch Ring Impact Tester.
4. Olsen-Boyd Automatic Cement Tester 2,000 lb. cap.
5. Olsen Direct Motor-Driven Hydraulic Brinnell Hardness Tester.
6. Rockwell Hardness Tester.

Furnace

1. 25 K. W. Hoskins Electric Furnace with automatic temperature control.
2. 5 K. W. Hoskins Electrical Furnace with manual control.

Machine Tools

1. 15-in. South Bend Motor Driven Lathe.
2. No. 6 Gardner Disc Grinder.
3. Racine 12 in. x 12 in. Power Hack Saw.
4. Racine 4½ x 4½ Power Hack Saw.
5. Barnes 20 in. Swing Stationary Head Drill Press.
6. Milling Machine.

Special machines for the study of various pipe coatings as well as impact machines for testing full sections of pipe are located in the basement. A special experimental unit has also been provided in the Burlington works where melting experiments can be conducted on special iron mixes and other metals. The unit is arranged so that the Laboratory developments along any line can be carried out in small scale production without interfering with the regular operations of the plant.

New Research Laboratories of U. S. Pipe and Foundry Company

The Library, which may also be adapted for consultation purposes, is filled with a vast assortment of technical and scientific volumes. Complete facilities are available for the projection of motion pictures. The Library and offices of the Research Department occupy the entire second floor of the new addition.

The completeness of facilities and convenient arrangement makes the entire new building well suited for the work for which it was designed.

New Distributors for Chain Belt Co.

Chain Belt Company of Milwaukee announces the appointment of two new distributors in the Construction Equipment field, namely: the Alabama Machinery & Supply Company of Montgomery, Ala., and the Concrete Products Sales Company, Ltd., of Oakland, Cal.

A Convincing Demonstration

At the recent convention of the American Water Works Association held at Amarillo, Texas, the various midwestern distributors of Pomona pumps installed an interesting exhibit in the Herring Hotel. A complete operating unit actually producing water in the hotel lobby attracted the attention of all the delegates. Apparently it was a happy occasion for the Pomona representatives judging from the smiles.

H_2O Via A Pomona

Distributor representatives of Pomona Pump Company, reading from left to right: H. W. Ross, Fred H. Holmes, S. F. Smith, R. W. Butters, A. V. Shuler, W. G. Price, and Joe Baker.

Gas Products Association

E. L. Mills, sales manager of the Bastian-Blessing Company, was recently elected president of the Gas Products Association. In electing a manufacturer of oxy-acetylene welding and cutting apparatus to this office a departure was made from the usual practice of electing a manufacturer of oxygen gas.

Mr. Mills was instrumental in raising thousands of dollars for the production of films for the Association and also has supervision of their production. The films portray the development of welding which makes possible a single pipe which is a thousand miles long; welded steel tubing aircraft fuselage; and the welded pipe joints in skyscrapers and other buildings for carrying of steam, liquids and gases. The films have been shown in many parts of the world and are available for associations and clubs.

Headquarters of the Association are in Chicago and officers and directors include: A. J. Fausek, Modern Engineering Company; W. H. Ballance, Electrox Company; H. B. Pearson, Compressed Gases, Inc.; M. L. Goodrich, Swift & Company; W. D. Flannery, K-G Welding and Cutting Co., Inc.; O. E. Engler, The Balbach Company; L. F. Loutrel, Shawinigan Products Corp.; E. H. Smith, Commercial Gas Co.; E. J. Flood, Page Steel & Wire Co.; and Parker B. Francis, Kansas City Oxygen Gas Co.

American Hoist & Derrick Opens Indianapolis Office

The American Hoist & Derrick Company announces the removal of its Dayton office to Indianapolis, Ind. The new office is located at 703 New City Trust Building. Mr. I. R. Bailey will have charge of the sales of the "American Revolver" and Mr. Wm. M. Schoen will represent the entire line of "American" hoisting machinery.

Both Mr. Bailey and Mr. Schoen are well known in Indianapolis.

Cutler-Hammer, Inc., is now occupying new offices in Philadelphia located on the tenth floor of the Terminal Commerce Building, 401 North Broad Street. Mr. F. J. Burd is manager of the Philadelphia district, where warehouse facilities are maintained for stocking C-H products, including motor control, wiring device and safety switch items for the convenience of patrons.

Lecourtenay Company, Newark, N. J., manufacturers of centrifugal pumps, announce the appointment of Mr. F. J. Moran as Philadelphia District Manager with offices in the Witherspoon Building.

Mr. Moran has for the past fifteen years been engaged in sales work for the General Electric Company in Philadelphia and, prior to that in New York and Chicago. He is a graduate of Sheffield Scientific School, Yale University.

Staynew Filter Corporation has moved its factory and home office to 25 Leighton Avenue, Rochester, New York. This removal to new and larger quarters was made in order to enable them to better handle their increased business.

Mr. L. J. Belnap, president of Worthington Pump and Machinery Co.

Worthington Pump Takes Over Gilman Company

Announcement has been made of the acquisition of the Gilman Manufacturing Company of East Boston, Massachusetts, by the Worthington Pump and Machinery Corporation. It is stated that the Gilman line of rock drilling equipment logically supplements the Worthington line of feather valve air compressors, and will aid in the expansion of their line of pneumatic service to mines, quarries, contractors and industry, which will henceforth be manufactured under one head. The combined experience of the Worthington and Gilman engineers is assured for each installation.

Although the Gilman products are already favorably known, the Worthington organization together with George H. Gilman and his staff, look forward to an increased prestige for the Gilman products under the new arrangement.

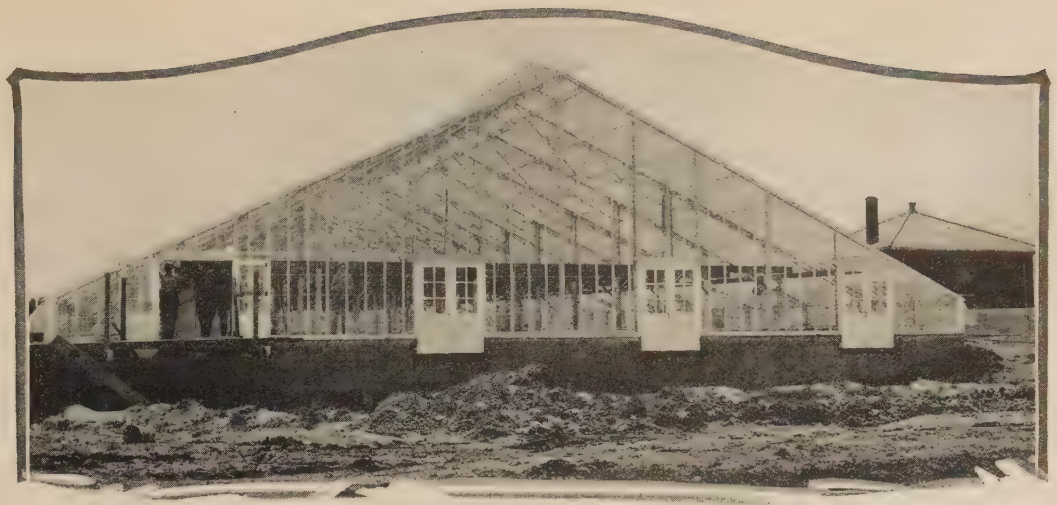
The general offices and works of the Worthington Pump and Machinery Company are located at Harrison, New Jersey, and branch offices are maintained in all the principal cities of the country and abroad.

New Sales Representatives for Paradon Company

The appointment of the following representatives for the sale and service of Paradon chlorinators has been announced by the Paradon Manufacturing Company of Arlington, New Jersey: For Florida (Jacksonville district) W. Austin Smith, 1207 Lynch Building, Jacksonville; for Tennessee (Memphis district) C. Fuson, 246 Court Avenue, Memphis; for Kansas district, The Smiley Equipment Company, Kansas City, Mo.

Federal Cement Tile Company of Chicago announces that it has acquired the American Cement Tile Manufacturing Company. Executive and general offices will be at Chicago with additional sales offices in New York, Philadelphia, Pittsburgh, Detroit, Boston, Buffalo, Birmingham and other cities. Plants are located in Hammond, Indiana; Lincoln, New Jersey; Wampum, Pennsylvania and Birmingham, Alabama.

Gilman Company Staff Now Members of Worthington Pump & Machinery Co.
Left to Right: Roy S. Hutchison, Charles A. Hirschberg, George H. Gilman, James R. Elmendorf, and Raymond J. Berke



The City of Dunkirk chose American-Moninger sludge bed enclosures

Since 1869

TWO American-Moninger glass all-steel sludge bed enclosures have recently been installed at the new sludge bed plant of the City of Dunkirk, New York. Special consideration was given to American-Moninger sludge bed enclosure on account of the all-steel acid and fume resisting construction built according to the approved engineering standards and practice which gives the positive assurance of the safety and strength of these structures.

When planning new sludge bed plants ask for an American-Moninger Engineer to discuss the plans with you and furnish preliminary sketches and specifications before you build. He will have some valuable suggestions for you. You will be under no obligation.

American-Moninger Greenhouse Manufacturing Company

Cleveland, Ohio., 11125 Lake Avenue

SOUTHWEST OFFICE
Oklahoma City, Okla., 2611 North Dewey St.

1365 Flushing Avenue
Brooklyn, New York

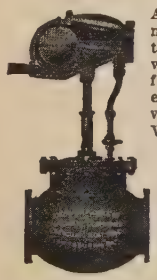
WESTERN OFFICE
Chicago, Illinois
1313 W. Randolph Street

No Water Hammer—No Bursted Mains

GOLDEN-ANDERSON

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Float Valves



Adapted to automatically maintain a uniform water level in feed-water heaters, tanks, reservoirs, and pans. Very sensitive.

Operating on ½-inch to ¾-inch variation. No exhaust or expensive water waste. Can be furnished for hot or cold initial water supply. Reliable and dependable under varying pressure.

Sizes ½-inch to 24 inches

REMEMBER
Valves cushioned at all times by air and water. No water hammer or bursting mains.

Automatic "Cushioned" Controlling Altitude Valves Cushion All Water Surges

Automatically maintain a constant stage of water in reservoirs, tanks and standpipes. They do away with the annoyances of Freezing Valves and Float fixtures inside of the Tanks or Floats and Fixtures outside of Tanks.

"Three Ways of Closing These Valves":
1st—Automatically, by water.
2nd—By electricity, if desired.
3rd—By hand.

May also be arranged to close automatically when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe. The double cushion effect of air and water eliminates water hammer. There are no dangerous surges to burst water mains. Write for details.

"Made with stop starter attachment for centrifugal pumps."

GOLDEN-ANDERSON VALVE SPECIALTY COMPANY
1329 Fulton Bldg., Pittsburgh, Pa.

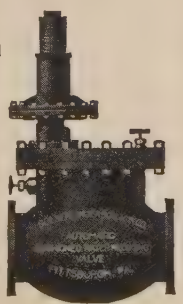
GOLDEN-ANDERSON

Patent Cushioned Water Relief Valves

1. Automatically relieve excess pressure.
2. Prevent stress, strain and bursting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and globe pattern. Sizes 3 to 24-inches.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Pressure Regulating Valves



1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

GOLDEN-ANDERSON

Pat. Automatic Double Cushioned Check Valves

1. Especially adapted for water service.
2. For high or low pressure.
3. Thoroughly cushioned. No chattering, hammering, or sticking.
4. Globe or angle patterns up to 24 inches.
5. Especially adapted for hydraulic elevator service.

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1. Automatically maintain uniform water levels in tanks, standpipe, etc.
2. Instantly adjusted to operate quickly or slowly.
3. Floats swivel to any angle—most satisfactory float valves known.
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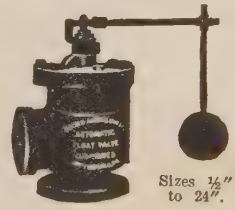
5. Cushioned by air and water.



Sizes ½" to 24".

W. S. Stewart to Represent Lincoln Electric in Cleveland

Announcement has been made of the appointment of W. S. Stewart, formerly in charge of the Pacific Coast offices of the Lincoln-Electric Company, to the position of district manager in charge of the Cleveland territory with offices at the factory, Coit Road and Kirby Avenue.

Mr. Stewart is a graduate of Yale University where he took a prominent part in athletics. He spent a number of years in the factory of the Lincoln company studying welding and was then transferred to the automatic arc welding department. From this department he was transferred to the Pacific Coast to handle sales. His wide experience has thoroughly qualified him for his new position.

Sales Personnel Changes in Wickwire Spencer Steel

A. A. Wilmot, who has been a member of the New York Sales Department of the Wickwire Spencer Steel Company for the past five years has been made assistant sales manager in charge of structural products at the Chicago office, 208 South La Salle Street, according to recent announcement.

G. L. Crawford, who has been a member of the sales staff at Chicago for the structural products during the past four years has been transferred to the office at Tulsa, Oklahoma, where he has been made assistant sales manager in charge of structural products. The Tulsa office is located at 1304 The Philtower.

B. L. Donahue Made District Manager

Cutler-Hammer, Inc., of Milwaukee, Wisconsin, manufacturers of electric control apparatus, has announced the appointment of B. L. Donahue as manager of the Buffalo district office. Mr. Donahue succeeds B. A. Hansen, who has resigned.

B. L. Donahue

Mr. Donahue has been connected with the Pittsburgh branch of the Cutler-Hammer company for the past eight years and is well known in the electrical field. He is a graduate of Penn State College, and holds the degree of B. S. in electrical engineering. He is a member of the Association of Iron and Steel Engineers, and of Sigma Tau Engineering fraternity.

Service Exchange has been helpful in securing desirable representation for the products of many manufacturers and in assisting distributors in building up their lines.

They Managed the Show

Left to right: O. E. Andreen, A. E. Loder, L. J. Fletcher, T. R. Farley and H. H. Sunderlin. These are the men who were responsible for the successful planning and carrying out of the Caterpillar Equipment Show recently held in Peoria, Illinois, by the Caterpillar Company.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

Of Water Works and Sewerage published monthly at Chicago, Illinois, for October 1, 1930.
State of Illinois } ss.
County of Cook }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared E. S. Gillette, who, having been duly sworn according to law, deposes and says that he is the business manager of Water Works and Sewerage and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Gillette Publishing Company, 221 East 20th St., Chicago, Ill.; Editor, H. P. Gillette, 221 East 20th St., Chicago, Ill.; Managing Editor, C. T. Murray, 221 East 20th St., Chicago, Ill.; Business Manager, E. S. Gillette, 221 East 20th St., Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Gillette Publishing Company, 221 East 20th St., Chicago, Ill.; H. P. Gillette, 221 East 20th St., Chicago, Ill.; E. S. Gillette, 221 East 20th St., Chicago, Ill.; Mrs. R. W. Hume, 303 S. Stone Avenue, LaGrange, Ill.; Winifred Gillette, 1125 Oak Grove Ave., San Marino, Calif.; Commonwealth Title Insurance & Trust Co., Chestnut and 12th Sts., Philadelphia, Pa.; Louise Forsythe, 13 E. Windermere Terrace, Lansdowne, Pa.; LaVerne Louer Hellyer, Ambassador Hotel, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholders or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

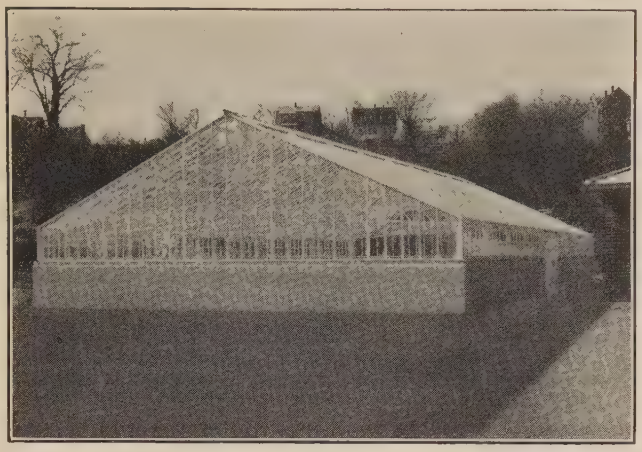
5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is (This information is required from daily publications only.)

E. S. GLLETTE,
(Signature of business manager.)

Sworn to and subscribed before me this 26th day of Sept. 1930.

KITTIE C. WOULFE,
(Seal.) Notary Public.

(My commission expires Feb. 8, 1934.)



This sludge bed is attractive, odorless and twice as efficient

King Sludge Bed Enclosures offer notable advantages over the older method of open-bed drying—advantages which the progressive community is quick to recognize.

In the first place, King Enclosures remove the only esthetic objections to disposal plants, viz., ugly appearance and odor. The King equipped plant is as attractive as a greenhouse, and all odors are effectively controlled by a special ventilation.

Sludge beds are doubled (sometimes trebled!) in capacity by King Enclosures. The drying continues regardless of the weather and sludge may be run to greater depths. Twice the population can be served with the same beds!

Examine the many King benefits. The houses themselves are rigidly constructed of durable, copper-bearing steel side posts. The steel rafters are spaced on 8'5" centers giving more supports per hundred feet of glass. All woodwork is of genuine, clear heart California Redwood, that wood which so superbly resists rot and decay century after century. Send for full information. No obligation!

The King Enclosure above is at the City of New London, Conn. Disposal Plant. Engineer: G. E. Watters.

KING CONSTRUCTION COMPANY

533 Wheatfield Street North Tonawanda, N. Y.

NEW YORK CITY PHILADELPHIA, PA. BOSTON, MASS. SCRANTON, PA.
TOLEDO, OHIO SCHENECTADY, N. Y. BRIDEPORT, CONN.

Bourbon Fire Hydrants, Gate Valves and Extension Valve Boxes

Water Works and Fire Department Supplies

The Bourbon Copper and Brass Works Co.

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SIMPLEX METERS

Accurate - Reliable - Simple
Easy to Check and Adjust

VENTURI TYPE

Manufacturers of

Meters and Controllers of Venturi Type; Gauges; Air and Vacuum Valves; Air Release Valves; and other Water-Works Devices

Write for Bulletins

SIMPLEX VALVE & METER CO.

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SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives of their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Manufacturer's representative located in New York City, now handling pumping machinery, would like to take on two or three additional lines serving the same field as his present account.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Manufacturer's representative, with warehouse facilities available, would like to secure additional lines in water works and sewerage and general contracting fields. Covers Houston and San Antonio territory.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Water works equipment distributor, covering northeastern Indiana, would like to secure representation of a line of chlorinators.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Water Works equipment distributor, covering northeastern Indiana, would like to secure representation of a line of chlorinators.

Wanted agency for any type of building specialties or contractors' machinery except mixers. Twenty years experience. Familiar with all types of contractors' machinery. Could act as sales manager for Atlantic Coast line with dealers.

West Coast distributing organization equipped to take on additional lines of equipment and supplies for water works and sewerage field.

Machinery distributor, established in Porto Rico and Santo Domingo, would be pleased to make arrangements to take on new lines in these territories.

Manufacturer's representative, covering Massachusetts, Rhode Island and southern New Hampshire, would like to secure line of speed reducers and gears.

Manufacturer's representative with 25 years sales experience, conversant with all types of pumps and their field, desires agency for either New York or export territory, or both.

Manufacturer's representative now handling centrifugal pumps would like to secure other lines in water works field. Covers eastern Pennsylvania, south Jersey and Delaware.

▼

Representatives Wanted

Manufacturer of special valve and hydrant lubricant wishes to establish distributing points throughout the country.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Manufacturer of centrifugal pumps for water works, sewage plants, sand and dredging plants, process industry, contractors, etc., desires to secure additional representation. Attractive territory available.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

Distributors wanted to represent improved type of snow fence. Good territory in various parts of country.

▼

Link-Belt Prepares for Future Business

Mr. Alfred Kauffmann, president of the Link-Belt, stated recently when interviewed: "Now, during the slack production period, is the time to perfect manufacturing processes and to prepare for future business. We believe in practicing what we preach."

In accordance with the policy expressed above a contract has just been closed for a powdered coal system entailing an expenditure of $125,000, for the Indianapolis foundry of this company. This improvement follows closely upon the completion of a new factory at Toronto, and the complete new plant for the Pacific Division at San Francisco.

A building to house the new coal system and alterations in the plant are a part of the improvements planned for at Indianapolis, where Link-Belt chains for elevating and conveying are made. It is said that the system will modernize the process of firing the melting and annealing furnaces and the heating of the boilers.

National Carbon Company to Sell "Gredag" Products

The Carbon Sales Division of the National Carbon Company, with headquarters in Cleveland, Ohio, which has been active for many years in the sales and distribution of carbon products, ha taken over the distribution of "Gredag" lubricants manufactured by the Acheson Graphite Corporation, a unit of the Union Carbide and Carbon organization.

It is stated that the many contacts with industrial plants and distributors of industrial products throughout the country which the National Carbon company maintains makes the addition of the line of lubricants a logical step.

Branch offices and service plants of the Carbon Sales Division are located in New York City, Pittsburgh, Birmingham, Chicago and San Francisco.

The Hercules Motor Corporation of Canton, Ohio, manufacturers of heavy-duty engines, announce a change in the address of the Hercules European representatives. Hereafter the headquarters of the Automotive Products Company, sole distributors of Hercules Engines and Power Units for Great Britain and Continental Europe, exclusive of U. S. S. R., will be located at Brock House, Langham St., London, W.1., England.

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Dr. St. John to Speak to Steel Founders

Dr. Ancel St. John, a leading authority on X-ray, will demonstrate the value of X-ray inspection of certain types of steel castings before the Steel Founders' Society at their meeting to be held at the Hotel Sherman in Chicago, December 11th.

Dr. St. John is a graduate of the University of Rochester and earned his Ph. D. through X-ray analysis with Clark University, and has held lecture courses in several colleges. He is said to be the first man to devote his entire time to industrial uses of X-rays and while employed as research physicist by Union Carbide and Carbon Corporation discovered pseudo-graphite and invented various analytical methods.

The latest achievement of Dr. St. John is the design and installation of the equipment for routine X-ray inspection of welded pressure vessels at the Barberton plant of Babcock and Wilcox Company. He is the organizer and president of the St. John X-ray Service Corporation of New York City.

Pipe Line Engineer Joins Caterpillar Forces

H. B. Owens for fifteen years in the producing end of the oil fields and natural gas business has joined the Caterpillar Tractor Company to develop this field for their tractors. Mr. Owens is said to have worked with some of the leading oil concerns including C. F. Camp, H. W. Cardwell Company and the Empire Oil and Refining Company. In his new position Mr. Owen's title is announced as Supervisor of Industrial Sales.

"An industry without precedence or pedigree," says Mr. Owens in speaking of the oil field and pipe line industry with which he has been associated.

"Remember that the first producing oil well was drilled in 1859, near Oil City, Pennsylvania and that until the coming of the internal combustion motor and especially the automobile, the oil industry was merely kerosene as far as the public was concerned.

"Now we have the advent of natural gas in the farming and industrial areas by way of pipe lines. This carries so much significance that the future economic growth of an entire territory will likely be materially affected with drastic changes wrought. For example, the placing of natural gas at the front door of every northern city at a cost greatly reduced from former methods of distribution seems not only possible but probable.

"Gas and gasoline piped to the doors of cities and farming areas opens up dependable unlimited supplies of the most nearly perfect fuel for industrial development in those areas most ideally suited to such developments. Great national resources

H. B. Owens

which have been dormant or impossible of exploitation only through lack of an economical fuel of high efficiency and usable offer unlimited practical application."

Mr. Owens states that reductions of costs, development and availability of source of supply and cheap transportation indicate the greatest natural gas and gasoline pipe line construction program ever undertaken. Mr. Owens' services are now available to Caterpillar dealers where industrial problems are up for solution, particularly in oil field and pipe line developments.

Price Made Vice-President Irving Iron Co.

Announcement has been made of the appointment of Paul L. Price as vice-president in charge of research and development for the Irving Iron Works Company of Long Island, N. Y. Mr. Price has been connected with this organization for nineteen years, and has recently served as treasurer and general manager. In his new office he will continue as chief engineer of the company.

The Irving Company are manufacturers of steel mesh grating flooring and steps, and steel mesh armoring for floors, bridges, highways, etc.

Personnel Plant Changes at Hercules Powder Co.

Several changes in the personnel in the supervision of explosives plant management were announced recently by officials of Hercules Powder Company. It is stated that a policy of promotion and rotation is followed, and W. C. Hunt, director of operations, announces the following changes:

To succeed the late C. F. Bierbauer as superintendent of the California plant, J. B. Johnson. To succeed Mr. Johnson as superintendent of the Emporium, Pa., plant, W. S. Brimijoin. L. W. Babcock succeeds Mr. Brimijohn as superintendent at Kenvil, New Jersey, and M. M. Inskeep succeeds Mr. Babcock as assistant superintendent of the Bacchus, Utah, plant. Mr. Inskeep is succeeded in turn as assistant superintendent at Pluto, explosives plant, Ishpeming, Michigan, by Andrew Van Beek.

Portland Cement Association Elects Kinney Vice-Pres.

Wm. M. Kinney of Chicago was elected vice president of the Portland Cement Association at its annual convention. Mr. Kinney's selection for this position of additional responsibility comes after twelve years service as general manager of the association, during which time the organization has increased its membership to ninety-five independent cement companies and greatly extended the scope of its operation. Other officers elected were Frank H. Smith, New York City, chairman of the board of directors, and George F. Coffin, Nazareth, Pa., treasurer. The president, it is stated, will be elected at a later date.

The Portland Cement Association has its national headquarters in Chicago. It occupies a five-story reinforced concrete building at 33 West Grand avenue. District offices are maintained in thirty cities throughout the United States.

T. C. Butler, Jr., Promoted

T. C. Butler, Jr., California sales manager of the Pomona Pump Company, of Pomona, California, for the past two years, has recently been promoted to the interstate sales department of that organization, according to recent announcement. It is stated that due to the tremendous increase in sales of the Pomona pumps throughout the country it became necessary to make this change.

Previous to joining the Pomona company Mr. Butler was for fifteen years research manager for the Indian Motorcycle Company, and during the war was sole representative of that company to the war department. He is a native of Georgia, his father having established the city of Butler.

Other personnel changes announced by Pomona include the promotion of C. L. Barrett to the position of California sales manager and G. L. Blanchard to that of assistant California sales manager.

Frank W. Lovett, Engineer, for Sewage Plant Service

Announcement has been made by the Link-Belt Company of Philadelphia of the appointment of Frank W. Lovett as engineer in charge of sewage disposal equipment in the Western territory.

Mr. Lovett is located at the company's plant office, 300 West Pershing Road, Chicago, and his services are available to municipal and industrial sewage disposal

Frank W. Lovett

plant engineers and managers. Mr. Lovett has been connected with the Link-Belt Company for thirteen years, and for eight years has been engaged in designing machinery for sewage treatment plants.

Distributor Notes from Hercules Motors

Four new distributors in the United States and Canada have recently been announced by the Hercules Motors Corporation of Canton, Ohio.

In Canada, J. S. Innes Ltd. of Toronto will represent the manufacturer in that city and its trading area. The Tractor & Thresher Company, Ltd., of Saskatoon will distribute Hercules engines and power units in the Canadian northwest.

In the United States E. B. Kelley Company of New York City will handle Hercules products in the metropolitan area and in Long Island City, Albany, Buffalo, Mt. Vernon, Rockville Center, New York and Neward, New Jersey, the business will be handled through their branch offices at these points.

A. H. Krigger & Company of Pittsburgh will represent the manufacturer in that city.

A. H. Armstrong Goes Into Private Practice

After thirty-nine years of service with the General Electric Company, holding such positions as consulting engineer for the transportation department and chairman of the railroad electrification committee, Mr. A. H. Armstrong has retired from the company to establish a private practice as a consulting engineer. His new office is located at 16 Troy Road, Schenectady, N. Y.

Mr. Armstrong is an outstanding authority on electric traction in the United States, and has contributed much fundamental information to textbooks on this subject, as well as exhaustive papers before various technical societies. His services as a consulting engineer on railroad electrification place at the disposal of his patrons the benefit of his wide experience in connection with such well-known electrifications as the Chicago, Milwaukee, St. Paul and Pacific, the Butte, Anaconda and Pacific, and the New York Central.

A graduate of Worcester Polytechnic Institute in the class of 1891, Mr. Armstrong entered the employ of the Thomson-Adriance Company. In 1897 he joined the railway engineering department of the General Electric Company, and has devoted most of his energies to the study of railroad problems since that time.

He is a member of the American Institute of Electrical Engineers, the National Electric Light Association, the American Electric Railway Association and the American Railway Engineering Association.

Henry Harnischfeger

News items of November 15th carried notice of the passing of Henry Harnischfeger, president of the Harnischfeger Corporation, one of the pioneer machinery companies of Milwaukee.

Mr. Harnischfeger was 75 years old at the time of his death and his life's history as reported in his autobiography which was published in December, 1929, is the typical romance of the foreign born boy coming to America and fighting his way to success against many hardships.

Born in Salmuenster Kreischlichtern, Hessen Nassau, a very old German town, in 1855, Mr. Harnischfeger was educated in a Franciscan monastery and considered becoming a monk. Abandoning this idea and also the thought of working as a tailor, he was apprenticed to a locksmith. When 15 years old his mother died and he persuaded his father to allow him to come to America.

His first work in this country was with the Singer Sewing Machine Company, making machine parts. For a few years he worked in various machine shops in and near New York and in 1877 journeyed to Milwaukee to take a position as foreman in the Whitehill Sewing Machine Company. Alonzo

Henry Harnischfeger

Pawling was a wood patternmaker for this company and later started the Milwaukee Tool and Pattern Company. Mr. Harnischfeger had loaned money on a mortgage to this company and later he and Mr. Pawling formed a partnership under the name Pawling & Harnischfeger which continued for many years. In 1910 a stock company was formed and eventually Mr. Pawling due to ill health relinquished his interest in the business some time before his death in 1914.

Glancing through the pages of Mr. Harnischfeger's autobiography one finds many names of manufacturing companies who have made history in the machinery business with whom Mr. Harnischfeger had dealings and in many cases which were started by men associated with him or by companies in which he had financial interests.

In 1892 Mr. Harnischfeger married Miss Marie E. Kauwertz and of his four children, two survive him, a daughter and his son Walter Harnischfeger who is identified with the Harnischfeger Corporation.

Willard Dow Heads Chemical Plant

The Dow Chemical Company of Midland, Michigan, called a special meeting of the board of directors following the death of Dr. Herbert H. Dow which resulted in the appointment of Willard H. Dow as president and general manager of the company. Mr. Dow has been a member of the board of directors for eight years, has served his company as assistant treasurer for three years, and has acted as assistant general manager for the past four years. His intimacy with the executive policies of the company and his many years of practical chemical experience fit him to head this $30,000,000 chemical organization.

The Dow company has been a progressive pioneer for the prevention of dust on gravel roads and streets, and Dowflake Calcium Chloride used for this purpose is also used as a concrete curing agent.

Willard H. Dow graduated in the class of 1919 from the University of Michigan with the degree of B. S. in chemical engineering. His practical work in the plant has made him familiar with the manufacturing processes used in producing more than 150 chemical products. He has stated that the progressive research policies of the company will continue to be its distinguishing factor.

F. F. Beall Made Director Continental Motors

Announcement has been made of the election of F. F. Beall to the Board of Directors of the Continental Motors Corporation. In 1926 Mr. Beall resigned from the Packard Motor Car Company to engage in the development of a new motor-fuel called "Gyrol" in conjunction with the Pure Oil Company and the Dawes Brothers of Chicago. This product is said to be meeting with a cordial reception, particularly in high-compression engines.

Mr. Beall received his early training with Brown and Sharpe Company. Since then his activities have been many and varied.

Their words have wings as swift as light

An Advertisement of the American Telephone and Telegraph Company

We live and work as no other people have ever done. Our activities are pitched to the swiftness of the instantaneous age.

Whatever happens, wherever it happens and however it may affect you, you may know it immediately over the wires or the channels of the air that carry men's words with the speed of light. Business and social life are free from the restrictions of time and distance—for practically any one, anywhere, may at any time speak with any one, anywhere else.

The widespread and co-ordinated interests of the nation depend upon an intercourse that less than sixty years ago was not possible in a single community. This is the task of the telephone wires and cables of the Bell Telephone System—to make a single community of our vast, busy continent wherein a man in Los Angeles may talk with another in Baltimore or a friend in Europe as readily as with his neighbor.

It is the work of the Bell Telephone System to enable friends, families and business associates to speak clearly and immediately with one another, wherever they may be. Its service is as helpful and accessible on a village street as in the largest cities.

To match the growing sweep and complexity of life in this country, to prepare the way for new accomplishments, the Bell System is constantly adding to its equipment and bettering its service.

To this end, its construction program for 1930 has been the largest in its history. This System at all times accepts its responsibility to forward the development and well-being of the nation.

AMERICAN TELEPHONE & TELEGRAPH CO. BELL SYSTEM AND ASSOCIATED COMPANIES

He Just Keeps Digging

To just keep digging isn't such a bad idea as is evidenced by results obtained by M. J. Gray and his associates of Pensacola, Florida, who for the past twenty years have used this method for locating both business and wells.

A recent contract awarded to Mr. Gray's company, the Gray Artesian Well Company, was for the drilling of a well at the Naval Air station at Pensacola. It is said that contracts are being awarded at this time in order to relieve the unemployment situation and that other contracts will follow in a short time.

Mr. Gray's company is operated on the theory that "there can be no monopoly of brains, brawn, courage and determination" and they set about proving their share of

M. J. Gray, General Manager, Gray Artesian Well Co.

these qualities in the manner in which they serve the users of water in Georgia, Florida, Alabama, Mississippi and Louisiana and other bordering states. Mr. Gray advocates in the water works field the same progressive methods shown in the construction field, that of replacing old, obsolete, inefficient equipment with the latest and most effective for serving the public needs.

Many Changes Announced by Caterpillar

The Caterpillar Tractor Company of Peoria, Illinois, has seen many new assignments in the sales department with the following lineup:

J. J. Crumbaugh, manager of the New York office has been transferred to the export department and assigned to work abroad. Arthur C. Jenvey, who has been assistant sales manager at Peoria, has been transferred to New York as manager of that office. W. H. Goodwin, who has been assistant sales manager in charge of the Denver sales division, has been sent to Peoria as general assistant sales manager to E. R. Galvin, sales manager.

A. E. Loder, general supervisor of construction and governmental sales has been transferred to the newly formed experimental and development division, which has headquarters in San Leandro, California. Mr. Loder will be the eastern representative of this division. C. A. Spears, supervisor of construction and governmental sales at San Leandro, has been sent to Peoria to succeed Mr. Loder.

L. G. Lawrence, district representative in Ohio, has been transferred to the western division as district representative at Los Angeles. Sam M. Miller, recently associated with Caterpillar, has been assigned to the territory as district representative formerly covered by Mr. Lawrence.

C. D. Price, special representative of the sales department in Peoria, has been transferred to the western division as district representative out of San Francisco. R. I. Wallingford, former district representative in the Amarillo territory has been assigned to special work. P. R. Ferrell has been made district representative in the territory formerly covered by Mr. Wallingford.

F. M. Stewart, district representative at Great Falls, Montana, has been assigned to special work. H. G. McClurg has been appointed district representative in the territory recently covered by Mr. Stewart. A. H. Snow, former district representative in the Grand Forks territory, has been transferred to the export department and will eventually be assigned to work abroad.

R. H. Gardner, recently assigned to Washington, D. C., to represent the Caterpillar Tractor Company

T. V. Marks, formerly on special work, has been appointed to succeed Mr. Snow. L. W. Werner, has been assigned to the Glendive, Montana territory. E. I. Stouffer will be assistant sales manager in charge of the Eastern portion of the Eastern sales division.

Ryerson Official Lectures on Special Steel

Mr. G. VanDyke, manager of special steels department of Joseph T. Ryerson and Sons, has been lecturing at various points throughout the country on alloy, tool and stainless steels. Some of the cities visited include Minneapolis, Cincinnati and Milwaukee where he has spoken to engineers and shop men.

Mr. Van Dyke has adopted for his method of presentation of his subject a lecture requiring about three hours for delivery followed by a two-hour demonstration including welding. The various characteristics of such products as high carbon stainless steel, low carbon stainless iron, high chrome stainless nickel alloys of the heat resisting type, are fully discussed. His talk is said to include the

G. Van Dyke, Manager Special Steels Dept., Joseph T. Ryerson and Sons

fabrication of the 18-18 type in detail in its general application to various industries, with a display of many samples.

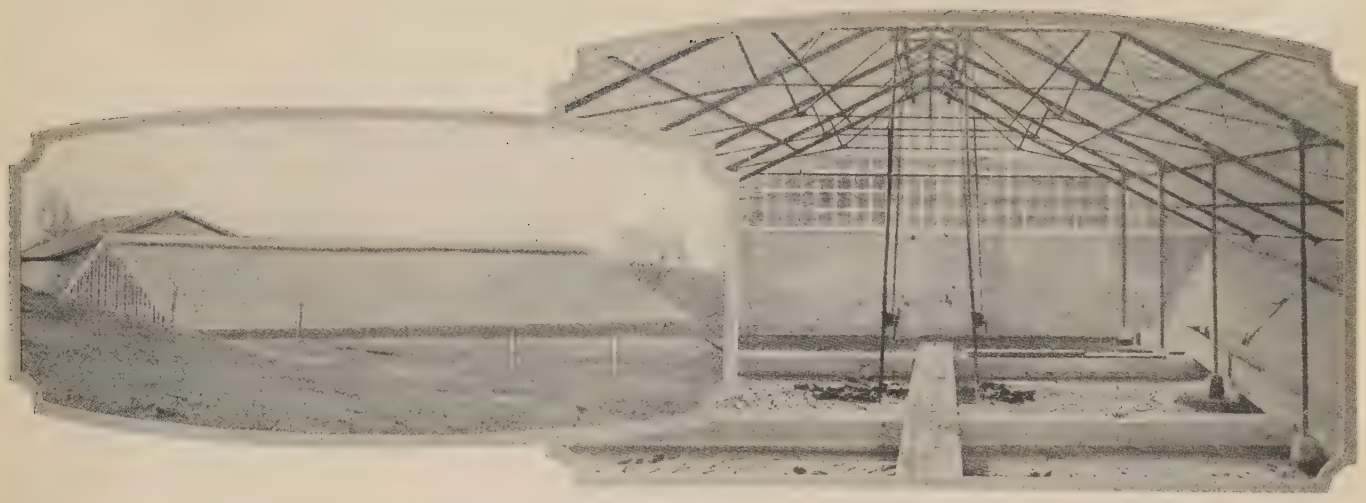
It is said that Mr. Van Dyke's lectures and demonstrations are given in such a non-technical manner that superintendents, shop foremen, welders and others whether they may or may not have had technical training find them easy to comprehend and all charts and tables used in the lecture are reproduced in mimeograph and supplied to all those attending the lectures.

Before concluding his series of lectures Mr. Van Dyke will visit many of the leading cities throughout the country in order to respond to the requests of those who have asked for meetings.

Bon Voyage

M. A. Waldo on board the liner, President Garfield, as it is leaving San Francisco harbor, enroute to Honolulu, Japan, China, the Philippines and Straits Settlements in the interest of the Novo Engine Company of Lansing, Mich.

Mr. Waldo expects to spend the next year in a special survey to ascertain the extent of the present and potential market for power units and contractors' equipment in the Far East.



Glassed-over enclosure in Marceline, Mo., gives good service

Since 1869

AFTER several years of service the glassed-over enclosure of this sewage disposal plant, used by the City of Marceline, Missouri, is still in good condition. This enclosure facilitates the drying out of the sewage.

It is a fact that American-Moninger all-steel sludge bed enclosures are acid and fume resisting and are built according to the approved engineering standards and practice.

American-Moninger has ample facilities for handling all types of sludge bed coverings and will gladly assist in solving your problems in glass coverings for sludge beds.

Write for our estimate, preliminary plans and specifications. No obligation on your part.

American-Moninger Greenhouse Manufacturing Company

Cleveland, Ohio., 11125 Lake Avenue

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Oklahoma City, Okla., 2611 North Dewey St.

1365 Flushing Avenue
Brooklyn, New York

WESTERN OFFICE
Chicago. Illinois
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WATER CONTROL

without floats or fixtures

A constant water level can be automatically maintained in reservoirs, tanks and standpipes by the use of

GOLDEN-ANDERSON Automatic Cushioned Controlling Altitude Valves

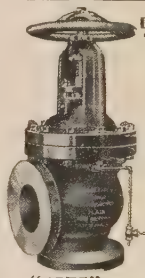
These valves are always cushioned in closing and opening. They are extensively used for automatically maintaining a uniform stage of water in reservoirs, tanks and standpipes. No valves inside. No floats or fixtures, inside or outside of tanks. No freezing troubles. Three ways of closing these valves:

1st—Automatically, by water
2nd—By electricity, if desired
3rd—By hand

Remember: Valves cushioned at all times by air and water. No water hammer or bursting mains.

"Made with stop starter attachment for centrifugal pumps."

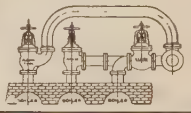
Golden-Anderson Valve Specialty Co.
1329 Fulton Bldg., Pittsburgh, Pa.



"4575"
Used by Steel Companies

Pat. Automatic Double Cushioned Triple Acting Non-Return Valves

1. Prevent shut-downs due to reversal of steam flow.
2. Instantly close and isolate a boiler when a tube bursts.
3. Cut off steam flow from every boiler instantly when a steam pipe ruptures.
4. Automatically cut a boiler into line.
5. Prevent backflow into cold boiler.
6. The only valves that can be tested in service.



Angle, Globe or Elbow

Patent Automatic Cushioned Controlling Float Valves

They carry a constant water level in feed water heaters by perfectly controlling the flow of makeup water.

Operated by protected enclosed copper float.

Cushioned by both air and water. Operate without hammering, sticking or chattering. No metal-to-metal seats. Made angle or straightway.

Sizes 1 in. to 24 in.

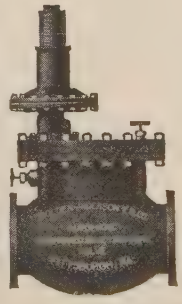
Pat. Automatic Double Cushioned Check Valves

1. Especially adapted for water service.
2. For high or low pressure.
3. Thoroughly cushioned. No chattering, hammering, or sticking.
4. Globe or angle patterns up to 24 inches.
5. Especially adapted for hydraulic elevator service.

Pat. Automatic Cushioned Water Float Valves

1. Automatically maintain uniform water levels in tanks, standpipe, etc.
2. Instantly adjusted to operate quickly or slowly.
3. Floats swivel to any angle—most satisfactory float valves known.
4. No metal - to-metal seats—no water hammer or shock.
5. Cushioned by air and water.

Sizes ½" to 24".



Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives of their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Water Works equipment distributor, covering northeastern Indiana, would like to secure representation of a line of chlorinators.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Manufacturer's representative, with warehouse facilities available, would like to secure additional lines in water works and sewerage and general contracting fields. Covers Houston and San Antonio territory.

West Coast distributing organization equipped to take on additional lines of equipment and supplies for water works and sewerage field.

Manufacturer's representative now handling centrifugal pumps would like to secure other lines in water works field. Covers eastern Pennsylvania, south Jersey and Delaware.

Diesel engine account, road building material and equipment line, and industrial equipment and materials seeking representation in south wanted by Florida distributor. Large warehouse facilities.

A Michigan distributor, with many years' experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing increased facilities in this region.

Michigan distributor would like to add two or three good lines to serve territory in southwestern part of state.

New York state distributor would like to add two or three lines to serve his territory.

Machinery distributor, established in Porto Rico and Santo Domingo, would be pleased to make arrangements to take on new lines in these territories.

Distributor located in Portland desires line of stationary diesel engines, from 75 to 150 hp. to serve western trade for driving rock crushers and industrial plants.

Distributor located in Virginia wishes to make connection to represent manufacturer of manganese crushing plates and jaw rock crushers.

Export manager for American manufacturer of road graders is in a position to handle an additional line of non-competing construction machinery, for manufacturer seeking foreign representation.

Manufacturer's representative located in New York City, now handling pumping machinery, would like to take on two or three additional lines serving the same field as his present account.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Distributor of building specialties covering a territory of 100 mile radius from Chicago is equipped to represent additional lines.

▼

Representatives Wanted

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Manufacturer's representative with 25 years sales experience, conversant with all types of pumps and their field, desires agency for either New York or export territory, or both.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Manufacturer of centrifugal pumps for water works, sewage plants, sand and dredging plants, process industry, contractors, etc., desires to secure additional representation. Attractive territory available.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Manufacturer of special valve and hydrant lubricant wishes to establish distributing points throughout the country.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of air compressors and contractors' tools has number of desirable territories open. Full co-operation will be extended to distributors.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

Distributors wanted to represent improved type of snow fence. Good territory in various parts of country.

Manufacturer of asphalt ingredient, adaptable for use in the road or industrial field, is seeking representatives for desirable territory in various parts of the country.

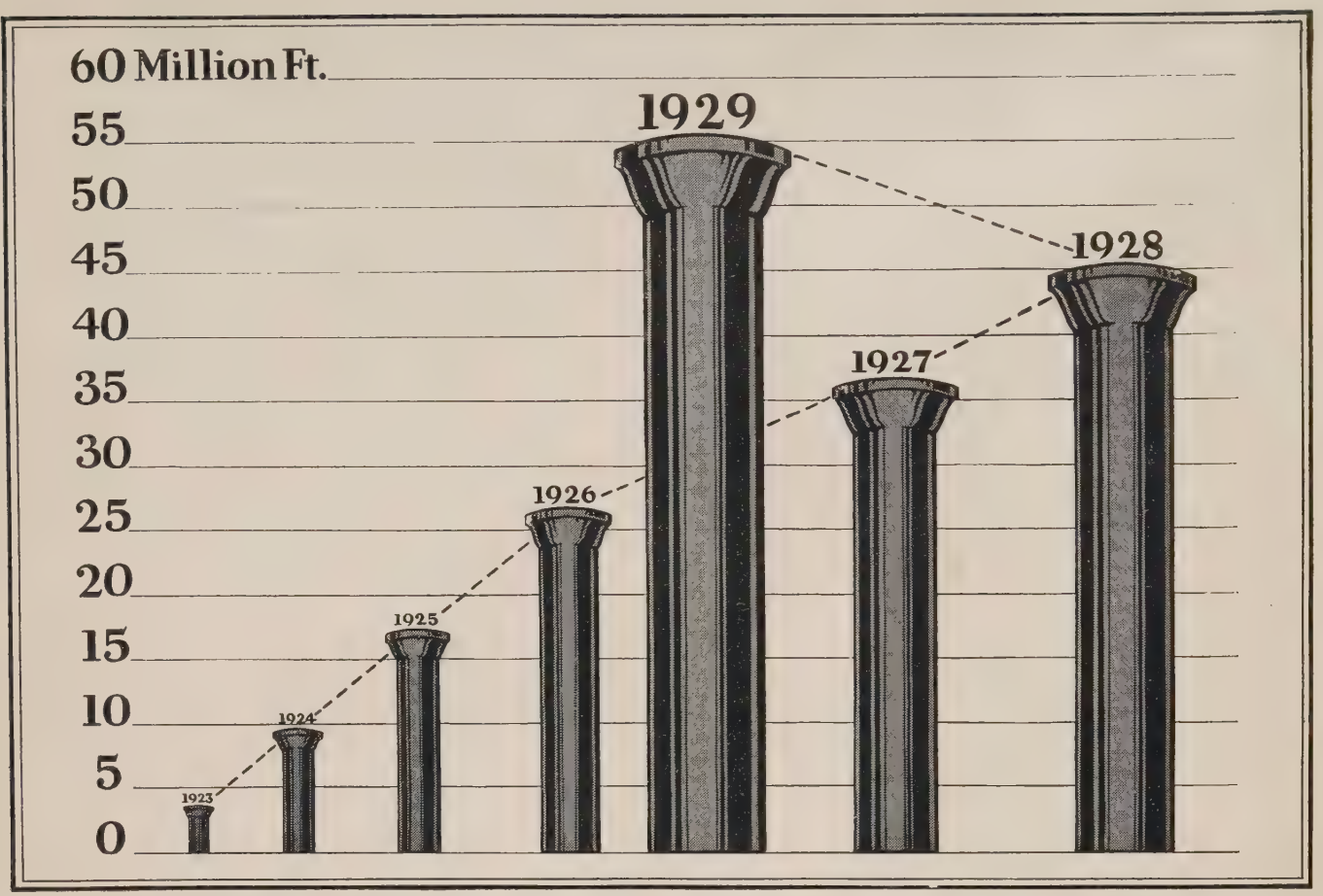
Attractive territory open in states south and west of Chicago by manufacturer of cut to length, easily erected standardized steel highway bridges, for spans up to and including 40 ft. Product sells to highway commissioners and superintendents.

Manufacturer of Transverse Testing Machines desires to build up distribution organization in this country and abroad.

Several desirable states open. Wanted distributing organizations covering entire states by manufacturer of mechanical spreader.

Territory open in several states for representatives to handle grade-rippers, scrapers and plows.

Open territory in New York and New England states for aggressive distributor wishing to take on line of hoisting machinery and air compressors.



. . . *today*, more than 10,227 miles of U.S. deLavaud Pipe are in service

In December 1929, more than 54 million feet, or 10,227 miles of deLavaud Pipe — manufactured by the U. S. Pipe and Foundry Company — were in service throughout the country. A mighty fine record of acceptance for this sturdy seven-year-old product!

The first year of its manufacture in the United States, more than three million feet of deLavaud Pipe were put down. Since that time, its popularity has increased by leaps and bounds. The above chart tells the story.

Strength, flexibility and greater carrying capacity are the outstanding reasons for deLavaud Pipe's wide acceptance. DeLavaud Pipe is produced by pouring molten iron into a rapidly revolving metal mold. Centrifugal force holds the metal against the sides of the mold and drives out impurities with a force many times greater than gravity. The metal mold is encased in a water jacket, the cooling action of which brings about the remarkably fine granular structure of the iron.

Immediately after coming from the machine, every length of deLavaud Pipe is uniformly annealed in a specially constructed furnace where controlled heat eliminates all possibility of casting strains.

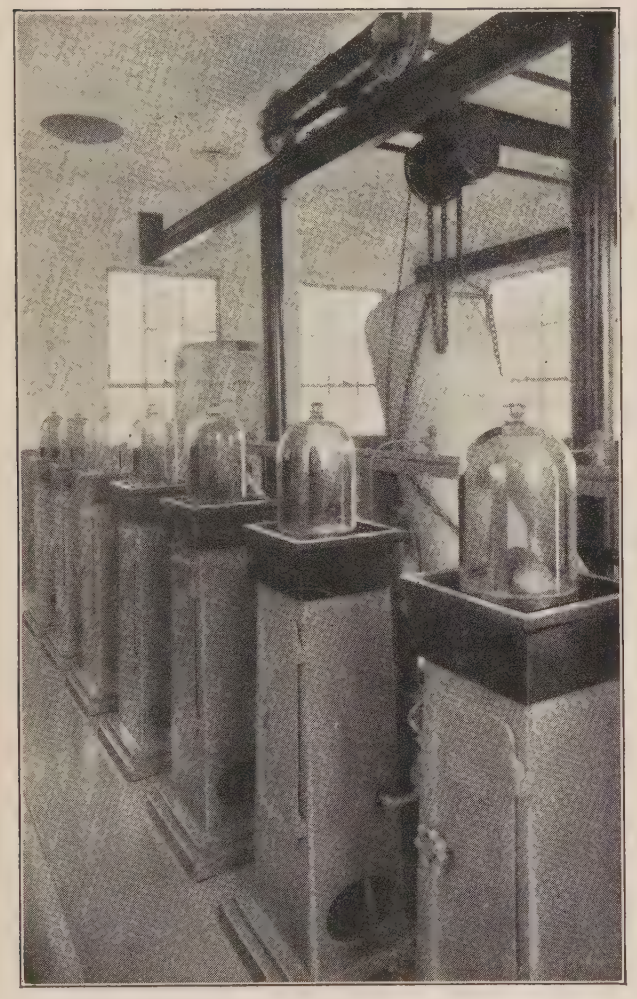
DeLavaud Pipe is manufactured in thicknesses and weights in strict accordance with the specifications of the American Water Works Association and the American Gas Association as well as the United States Government Specifications. The new deLavaud Handbook gives complete information. Write for your free copy today.

United States Pipe and Foundry Co., Burlington, N.J.

Sales Offices:
New York, Philadelphia, Pittsburgh, Cleveland, Buffalo, Chicago, Dallas, Birmingham, Kansas City, Minneapolis, Seattle, San Francisco, Los Angeles

Our pipe bears the "Q-Check" trademark of The Cast Iron Pipe Research Association

327 VACUUM CHLORINATORS



Seven W&T solution feed VACUUM CHLORINATORS (Tyoe ASV) on the LOS ANGELES, Calif. Water Supply

FIFTY three cities are on the American Medical Association Honor Roll.

Fifty three cities with a typhoid death rate of less than two per hundred thousand — and chlorination played a vital part in making this splendid record.

But — the significant fact is this — 327 W & T Solution Feed VACUUM CHLORINATORS are sterilizing the water supplies, disinfecting the swimming pools, chlorinating the sewage in these justly honored fifty three American municipalities.

Three thousand Solution Feed VACUUM CHLORINATORS are now in daily service.

Their ease of operation, their low maintenance costs have been proven. Their absolute dependability is attested by the record of these 327 machines.

NO VACUUM CHLORINATOR HAS EVER WORN OUT

Ask for Technical Publication 38

WALLACE & TIERNAN CO., INC.

Manufacturers of Chlorine Control Apparatus

NEWARK, N. J.

BRANCHES IN PRINCIPAL CITIES

A Product of

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"The only safe water is a sterilized water"

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